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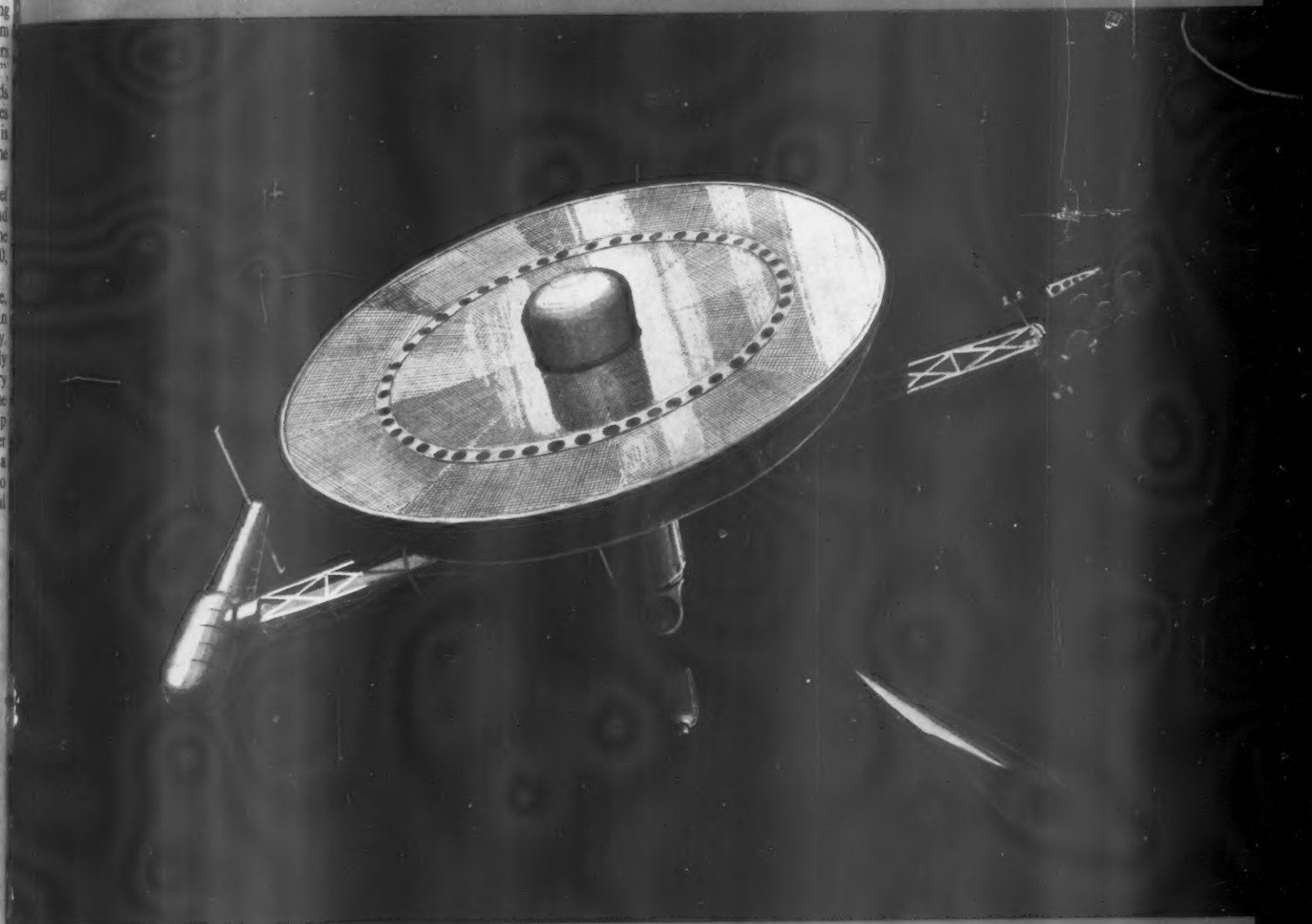

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BIS

PRICE 3/6

PUBLISHED BY THE BRITISH INTERPLANETARY SOCIETY

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It's dazzling when you look up!

It's hard to look the sun in the eye. Just as it's hard to contemplate the possibility of flight into Space. Yet the possibility, like the sun, is clearly there. Will it be realised in our children's lifetime, or theirs? Nothing is certain. But the promise of this International Geophysical Year is that it will bring such an achievement appreciably closer.

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Editorial

Events continue to move quickly, and since the publication of our last issue there have been several notable developments. The Russians have launched a third and still more massive Sputnik; the Americans have announced that they plan to send a vehicle to or round the Moon—perhaps the attempt will have been made by the time that the present issue is in your hands; and at long last there are official indications that Britain, too, is to play an active instead of a passive rôle. Let us hope that in the very near future a more adult political policy will allow all scientists to work together instead of being forced to waste much of their time upon the lunacy of preparations for war. The responsibility for this lies with us all.

This issue concludes Volume 1 of *Spaceflight*. It would be rash to forecast what will have happened by the time Volume 2 also is complete; meanwhile, I wish to express my gratitude to the Editorial Board, to all others who have helped to produce the periodical, and—most of all—to our contributors. We have done our best to give you the sort of periodical which you want; we can only hope that the result has satisfied you.

August 9, 1958. PATRICK MOORE

COVER

The Space Station—Drawing by R. A. Smith.

Over 200 kilowatts of power for the station is obtained from a mosaic of photo-electric cells carried by the 200-ft. diameter disk, the face of which is protected by a transparent meteor bumper. Behind the disk is a shallow double-walled drum 150-ft. in diameter. This contains living quarters, workshops, laboratories, storerooms and all operating plant. Several concentric galleries are envisaged, but the permanently inhabited one is outermost. Disk and drum revolve as a single unit, at a rate providing normal gravity in the inhabited outer gallery. A normally stationary but rotatable lattice boom carries at one end gimbal-mounted radio arrays and television cameras. Situated at the other end of the boom is an astronomical observatory equipped with a 100-inch Cassegrain telescope similar to that described by R. A. Smith in *J.B.I.S.*, No. 79, 1958. Access to the observatory is obtained via airlocks and the tunnel up the boom. The observatory is rotatable and the lattice boom movable in order to sight the telescope in any direction. One central turret is a no-gravity laboratory; the other a vestibule and spaceship-tender berth.

SPACE MEDICINE SYMPOSIUM: 25TH ANNIVERSARY OF THE BRITISH INTERPLANETARY SOCIETY

SPACE MEDICINE SYMPOSIUM: 25TH ANNIVERSARY OF THE BRITISH INTERPLANETARY SOCIETY

On October 16–17, 1958, the British Interplanetary Society is holding a Space Medicine Symposium at the headquarters of the British Medical Association, B.M.A. House, Tavistock Square, London, W.C.1. The Royal Air Force Institute of Aviation Medicine is co-operating, and there will be speakers from the U.S. Office of Naval Research and various foreign institutions. Associated with the Symposium (but open also to members of the Society who do not wish to attend the Symposium) is the dinner being held as part of the celebrations of the 25th anniversary of the Society's foundation. This will take place at the Waldorf Hotel, Aldwych, London, W.C.2, on Friday, October 17, 1958, at 7.30 for 8 p.m.

A final announcement for both these functions has appeared in the July-August issue of the *Journal* of the British Interplanetary Society (p. 483–4) and further particulars are available from the Secretary. Early application is desirable, in view of the limited accommodation at both functions.

Sputnik III

By MAURICE ALLWARD

Russia's new satellite, and its significance in the development of astronautics.

May 15, 1958, witnessed another spectacular advance in the astronautical time-table. The Russians launched their third artificial satellite, Sputnik III, the sheer size and near-3,000 lb. weight of this dwarfing even the remarkable dog-carrying Sputnik II of 1957.

Before describing the satellite in detail it is instructive to note how rapid developments in astronautics are already effectively foreshortening estimates for the achievement of space-flight which, when they were made only five short years ago, seemed optimistic.

In 1953, a paper by A. V. Cleaver titled "A programme for achieving interplanetary flight" was read to the Society at the October meeting. In this intensely interesting paper Cleaver summarized the progress made up to that time and then, basing his conjectures upon current and anticipated developments, made some predictions as to the manner in which space would be conquered, and the probable time taken.

Broadly speaking, Cleaver considered that interplanetary flight would be achieved in three basic stages:

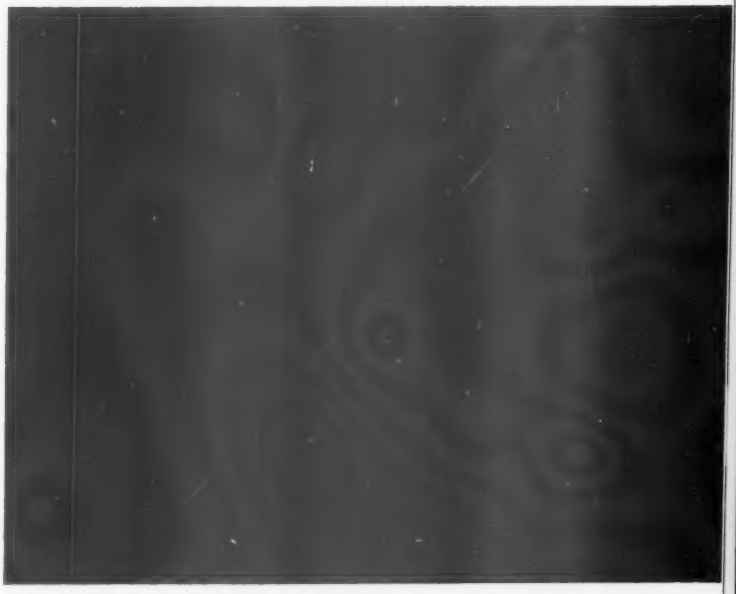
Phase 1. This covered the programme up to, and including the establishment of an instrument-carrying, unmanned, satellite.

Phase 2. This took the programme to the stage of achieving regular manned orbital flights round the earth, with occasional expeditions (manned or otherwise) to circumnavigate the Moon.

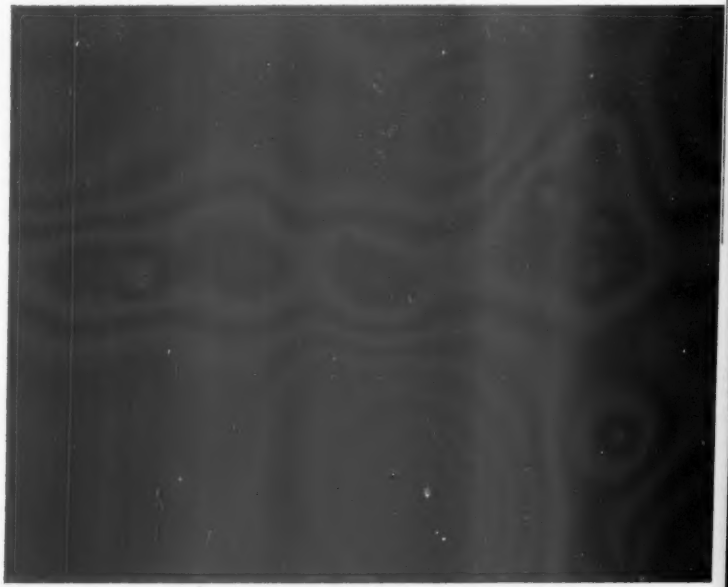
Phase 3. This, the final and conclusive period, envisaged the achievement of true interplanetary flight, with landings on the Moon.

ASTRONAUTICAL TIME TABLE

Development	Time scale envisaged in 1953 B.I.S. paper	Actual time scale
First unmanned satellite	1965	1957—Sputnik I, 183 lb. —Sputnik II, 1,200 lb. 1958—Explorer 1 —Vanguard 1 —Explorer 3 —Sputnik III, 2,914 lb. —Explorer 4
First manned piloted Earth satellite	1975	1958—Moon probes planned
First Moon probes ..	1985	1959—First flights of North America X-15. May be capable of orbital flight
Mars and Venus probes	1990	?
First landing on Moon	2000	?



A.E.S. 6 Rocket. From Chelmsford, Essex. 1958 July 9. 104.40 mins. Approaching from S.W. *Brian F. Davies*



A.E.S. 6 Rocket. From Chelmsford, Essex. 1958 July 9. 104.41 mins Leaving towards N.E. *Brian F. Davie*

As far as the time scale was concerned, it was considered that the first satellite would "probably be launched by about 1965". Following this success would come larger and more ambitious satellites. For phase 2 Cleaver stated: "It seems possible that a relatively small piloted Earth-satellite-vehicle might take up its orbit by about 1975". After this, round about 1980, would come the sending of one or two small guided missiles to circumnavigate the Moon without landing. From 1980 would come phase 3, with manned, or unmanned, expeditions to Venus and Mars, with the first landing on the Moon taking place at the turn of the century.

To-day, barely 4½ years after this paper was read, we find phase 1 virtually completed, and aspects of phase 2 under active consideration. In fact, both phase 2 objectives now seem possible of realization within the time span then allocated to phase 1!

Sputnik III, like its U.S.S.R. predecessors, was launched into a polar orbit, at an angle of 65° to the equator. Initial Russian reports placed its apogee at 1,165 miles, the satellite taking 106 minutes to complete a revolution, this orbit having been chosen to "ensure scientific investigations in the most interesting range of altitudes."

An editorial in the Moscow newspaper *Pravda* stated that "after the carrier rocket with the Sputnik had reached, on a predetermined flight trajectory, a speed of over five miles a second, the Sputnik was detached from the carrier rocket by means of special devices and began to circle the Earth in an elliptical orbit".

As the satellite left the carrier rocket, it cast off its protective cone and shields. Shaped like a cone, the satellite is nearly 12 ft. long, with a maximum diameter of 5 ft. 8 in., not counting the protruding aerials. Its total weight is 2,919 lb., of which over 2,000 lb. is the instrumentation and power supplies.

The third Sputnik is thus much superior to its two predecessors, which weighed 184 lb. and 1,000 lb. respectively; these in turn may be compared with the 30 lb. and 3·25 lb. of the American Explorer I and Vanguard I satellites.

Structural Details

The outer skin of the satellite is made of aluminium alloys, the surface like that of the earlier Russian satellites being polished and specially treated so that its coefficients of radiation and absorption of solar radiation have the required values. The removable back plate is bolted to the frame, the joint being made airtight with a special sealing compound. Before launching, the interior was filled with gaseous nitrogen.

Inside the shell a large magnesium alloy frame bolted near the base supports the following: radio telemetery device, radio gear for measuring the satellite's co-ordinates, a timer, a heat regulator and thermometer, and automatic devices for switching various instruments on and off.

A second frame nearer the nose supports the main recording instruments, together with the power supplies.

The sensors of the various instruments are arranged according to their use. The magnetometer has been placed in the front of the cone, as far away from the rest of the equipment as possible. Photomultipliers, used to record the Sun's corpuscular radiation, are attached to the fore part of the shell. One magnetic and two ion manometers for measuring pressure in the upper layers of the atmosphere have been placed in cylinders welded to the shell of the fore part of the Sputnik. Installed near them are two electrostatic fluxmeters, used to measure the electrical charge and the intensity of the Earth's electrostatic fields, and a tube of a radio-frequency mass spectrometer to determine the composition of ions at great altitudes.

Spherical ion screen traps, for measuring the concentration of positive ions as the satellite moves in its orbit, have been installed on two tubular rods attached by hinges to the shell of the Sputnik's body.

While the satellite was going up, the rods with the traps were pressed against the surface. After the satellite had been placed in orbit, the rods turned on their hinges into a position perpendicular to the side.

Four sensors for registering hits by micrometeors are installed on the back end-plate.

The fore part of the satellite was covered with a special cone which was cast off when it had entered its orbit. This cone protected the fore part, with the sensors installed on it, from thermal and aerodynamic impacts when the carrier rocket was passing through the dense layers of the atmosphere. The cone consisted of two half-shells which separated when they were jettisoned. In addition to the protective cone, a considerable part of the outer surface of the satellite was covered, during the ascent, by four special shields hinged to the body of the carrier rocket. When the Sputnik separated from the carrier rocket these shields remained attached to the rocket.

A number of aerials, in the shape of rods and tubular structures of a complex form, are attached to the outer surface.

The multi-channel radio-telemetering system installed has a high resolving power and is capable of transmitting an exceedingly large amount of information on the scientific measurements being carried out. The radio-telemetering system also includes a number of recorders which continually "memorize" the data of the scientific measurements as the satellite moves along its orbit. When it flies over special stations erected on Soviet territory the "memorized" information is transmitted from the Sputnik at great speed.

An electronic timer automatically controls the operation of all the scientific and measuring apparatus, periodically switching it on and off. This timer also periodically transmits the very accurate time signals necessary for the subsequent reduction of the results of the transmitted data to astronomical time and geographical co-ordinates.

A stable temperature is ensured by a system of thermal control, which has been much improved as compared with that used in the first Russian satellites. The

temperature is regulated by measuring the induced circulation of nitrogen gas, and by changing the coefficient of radiation on the outer surface. For this purpose controlled shutters, consisting of 16 separate sections, have been installed. The shutters are opened and closed by means of electric drives thereby controlling the thermal regulation system.

Instrumentation

As might be imagined, full use appears to have been made of the Sputnik III's 2,000 lb. payload, and complex instrumentation is fitted. The following equipment is installed:—

Corpuscular indicators.

Solar electromagnetic radiation includes the infra-red, visible, ultra-violet and X-ray regions of the spectrum. Ionized gas consisting of electrons and ions is erupted from the Sun into interplanetary space, and as the gas moves away from the Sun, part of the ions are neutralized, i.e., they are turned into ordinary atoms. The particles erupted from the Sun are usually called the Sun's corpuscular radiation, and according to various estimates, have a velocity of several thousands of miles per second near the Earth.

Information about this corpuscular radiation is very meagre. Two corpuscular indicators are installed, and consist of fluorescent screens covered with thin aluminium foil of varying thickness. In this way a rough sorting of the corpuscles according to their penetrating power is achieved.

Diaphragms which limit the solid angle of the trappings of the corpuscles are placed in front of the fluorescent screens. Under the influence of the corpuscles the screens grow luminescent, in the same way as the cathode ray tube in a television set does when it is irradiated by the electronic beam. The radiation of the screen is received by a photo-electronic multiplier. Its signal is "memorized" by a special device and then transmitted by the radio-telemetering system. The Sputnik is rotating upon its axis, and this rotation is used to determine the direction from which the corpuscles come.

In addition to registering corpuscular radiation the equipment is also enabling scientists to obtain additional information about X-ray radiation, as the indicators record this also.

Micrometeor counters.

We know that tiny solid particles—micrometeors—move in interplanetary space. Invading the Earth's atmosphere, they burn up in it. The luminescence, which can be seen with the naked eye or through a telescope, is produced only by the relatively larger particles. The smallest and, it may be assumed, the most numerous particles with a diameter of a few microns, create such an insignificant luminescence that it cannot be detected either by optical means or by other means of observation from the Earth's surface.

The study of this interplanetary "débris" is of importance for astronomy, geophysics and astronautics and also for the solution of problems concerning the evolution and origin of planetary systems, since it will make it possible to solve a number of problems vital for contemporary theories of cosmogony.

It is also very important to have a precise knowledge of the general quantity of meteoric substance which falls on the Earth's surface during a definite period of time. It is necessary to take into account the effect of the blows of meteoric bodies on the outer shell of rockets and artificial satellites and also on instruments installed on them, for example, on the surface of optical instruments which, as a result of collisions with micrometeors, might cease to be transparent and become opaque, on the active surface of solar batteries, etc.

Account must also be taken of the danger of satellites, and especially interplanetary rockets, colliding with larger particles. Although there is little probability of such a collision, the possibility does exist and it is important to be able to assess it properly.

The Sputnik III incorporates one of the simplest and at the same time most sensitive methods of recording the intensity of these micrometeors. This is the use of piezo-element pickups, which convert the mechanical energy of the striking particles into electrical energy.

The value of the electrical impulse arising in such a pickup depends on the velocity and mass of the striking particle, while the number of impulses is equal to the number of particles colliding with the surface of the pickup. Electrical impulses from the pickups are transmitted to the input of an electronic block, in which the impulses are counted and their values are registered.

Magnetometer.

The distribution of the Earth's magnetic field as regards its value and direction has been studied in considerable detail only in direct proximity to the Earth's surface. These data are extensively used in prospecting for minerals, in the navigation of ships and aircraft, etc.

The nature of the geomagnetic field is unknown, but as a result of measurements of the intensity of the geomagnetic field made in special observatories over a long period it has been established that there are decided fluctuations. The most intensive changes in the magnetic field have come to be known as magnetic storms.

An analysis of the observations seems to indicate that the main part of the geomagnetic field and its secular variations originate from sources located inside the Earth. On the other hand, the main sources of short-term variations of the geomagnetic field and magnetic disturbances are located outside the Earth, in the upper layers of the atmosphere.

To study the distribution of the geomagnetic field a magnetometer is installed, specially mounted so that the measuring instrument is automatically oriented in the direction of the full vector of the field, whatever the orientation of the satellite.

Moving in its orbit the Sputnik crosses the ionized layers of the atmosphere many times, and a magnetic survey over the entire globe is made within a matter of

hours. It is, in fact, providing an exceptional opportunity for studying the Earth's magnetic field.

Electrostatic fluxmeters.

As a result of a number of processes both in interplanetary space and in the atmosphere itself, the Earth, together with its atmosphere as a whole, acquires a certain electrical charge. The electrical field created by this charge should affect the velocity and direction of charged particles flying in interplanetary space. It can influence a number of geophysical phenomena (auroræ, etc.). Data on the electrical fields in the upper layers of the atmosphere can be of essential help in establishing the reason for the existence of the negative charge of the Earth and the positive charge of the atmosphere, which creates a difference in potential of several hundred thousand volts between the Earth and the ionosphere.

To gather data on the electrostatic fields two sensitive electrostatic fluxmeters with common control circuits are fitted. The complete installation is designed as two instruments, placed symmetrically on the side surface of the satellite.

An essential part of each instrument is the measuring electrode—a plate, consisting of 10 sections, connected with the body of the satellite by a resistor.

The surface of the plate is, so to speak, part of the surface of the body. This plate is periodically screened by another plate—a screen rotated by an electric motor. Since the measuring plate is part of the surface, when it is open it has part of the satellite's own charge and the charge induced by the electrostatic field outside. When the plate is screened, the charge flows from it.

In the course of the screen's rotation the charge of the measuring plate periodically flows from it along the resistor, creating a varying voltage, the value of which is proportional to the value of the charge of the plate. This voltage charge is amplified, rectified and fed into the input of the radio-telemetering system. The system of measurement adopted makes it possible to determine the value of the electrostatic field, and the use of two symmetrically placed instruments of the electrostatic fluxmeter provides the possibility of determining, not only the Sputnik's own charge, but also the electrostatic field outside.

A special control system enables the reliability and accuracy of the measurements to be checked while the equipment is working.

Ion screen traps.

There are three basic kinds of free charged particles in the ionosphere—positive ions, negative ions and electrons. The sum of the concentration of negative ions and electrons equals the concentration of positive ions. The ionosphere is electrically neutral. Therefore, by measuring the concentration of positive ions, it is possible to determine the complete concentration of free charged particles.

For measuring the concentration of positive ions along the orbit, two spherical ion screen traps have been installed on the surface of the Sputnik III. A spherical collector with a negative potential in relation to the shell has been placed in each trap. The electrical field thus created gathers on the collector all the positive ions that enter the trap and ejects from it the negative particles. The instrument is capable of measuring concentrations of from 10,000 to five million ions in a cubic centimetre.

Measurement of the concentration of positive ions will make it possible, for the first time, to obtain information on the full concentration of charged particles in the ionosphere over various geographical areas of the Earth at different heights, and also information on changes in concentration in passing from the region lit up by the Sun into the region of shadow. This information is very important for understanding the processes of the interaction of solar radiation with the Earth's atmosphere.

It may be expected that the measurements of the concentration of positive ions will yield new data on the structure of the outer region of the ionosphere, supplementing information on this region obtained by means of rockets and the first satellites. It can also be expected that the extent of the variations of the ionosphere will also be measured.

Mass spectrometer.

The Earth's atmosphere consists of a mixture of different gases. At the surface we have been able to measure its composition accurately. Information regarding the upper layers, however, is rather contradictory. One of the major characteristics of the gases contained in the atmosphere, and also of all essential chemical elements in general, is their atomic and molecular weight, which is expressed in standard units—the so-called units of atomic mass. The unit of atomic mass is taken to be a value equal to one-sixteenth of the weight of an atom of oxygen. The molecular weight of oxygen, which consists of two atoms, equals 32. The atomic weight of nitrogen equals 14, and its molecular weight, 28.

An analysis of the molecular and atomic weights of various compounds and mixtures indicates their chemical composition. Instruments known as mass spectrometers are used to determine the atomic and molecular weights of the elements and their compounds which make up a given mixture.

A mass spectrometer is installed in the Sputnik III to determine the mass spectrum of positive ions contained in the Earth's ionosphere. When this ionic mass becomes known it will be possible to draw conclusions regarding the chemical composition of the ionosphere.

Cosmic ray detection.

Previous articles in *Spaceflight* and our contemporary the *Journal*, have indicated the importance of the study of cosmic radiation to interplanetary flight. This radiation comprises tiny particles of matter, travelling at speeds approaching that of light itself, and apparently originating in distant realms of outer space.

Opening of All-Union Industrial Exhibition in Science pavilion (U.S.S.R.)

A cosmic ray detector incorporating a Cherenkov particle counter is installed in the Sputnik III. This counter operates on the basis of the use of the Cherenkov radiation which arises if a charged particle moves in a substance at a velocity exceeding the speed of the propagation of light in that substance.

The Cherenkov counter consists of a plexiglass cylinder detector to the end face of which a photoelectronic multiplier is attached. When a cosmic ray particle with a velocity close on 186,000 miles per second flies through the detector it creates Cherenkov radiation in it. The speed of propagation of light in plexiglass is approximately 124,000 miles per second, and Cherenkov radiation can therefore arise in it.

The light which arises in the detector is received by the photomultiplier, which transforms it into an electrical signal and amplified it to the value necessary for registration by the instrument. The instrument sorts out the signals into two groups, conforming to the passage through the detector of particles with a charge of more than 30 and particles with a charge of more than 17. Each time a particle flies through the Cherenkov counter there is a signal indicating the group to which the nucleus that entered the instrument belongs.

The Russians hope to use this instrument in experiments to detect the presence of gamma rays in the cosmic radiation and, if possible, determine their direction of travel. Gamma rays should travel in space in practically a straight line (in contrast to cosmic rays which are affected by external influences such as the Sun and Earth's gravitational fields). In discovering the direction of travel of the gamma rays, it will be possible to indicate the direction of the source. If the attempt is successful, a new method of studying the universe will be available.

Manometer.

Investigation of the changes in pressure and density at different altitudes is among the major geophysical studies of the upper atmosphere. If these two parameters are known, it is also possible to determine the temperature of the atmosphere at high altitudes.

To add to the information obtained on previous satellites manometers installed on the outside surface are connected with measuring instruments placed inside. Pressure within the range of 10^{-5} to 10^{-7} of a millimetre of the mercury column is measured by a magnetic manometer, and in the range of 10^{-6} to 10^{-9} of a millimetre by ionising manometers.

The timer governing the operation of all the instruments is made entirely of semiconductors. A feature of the instrumentation, in fact, is the extensive use of semiconductors, a total of several thousand being used.

[*Continued on page 327*

Why Send a Rocket to the Moon?

By GILBERT FIELDER, B.SC., PH.D., F.R.A.S.

Will it be possible, in the near future, to send an unmanned rocket vehicle either around the Moon or to land upon the Moon's rugged surface? And if so, how would we benefit from such an operation?

Before we attempt to answer these questions let us note, briefly, some of the things which could possibly be clarified by the use of rockets. Observations of the way in which the Moon moves have indicated that the Moon is nearly, but not quite, spherical. With the exception of eclipses caused by the shadow of the Earth, the face of the Moon which we cannot see experiences conditions similar to those of the known face. The other side of the Moon may therefore be very similar to the side which is turned permanently towards the Earth, but this is a matter of uncertainty. It would be a fascinating experiment to attempt to gain pictures of the averted hemisphere of the Moon.

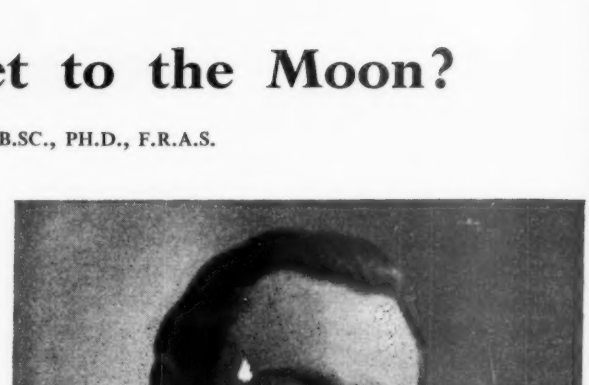
There is some evidence that there are craters on the permanently invisible part of the Moon, for some of the bright streaks (the so-called rays) which are known to radiate from craters, appear to cross over from the unknown side. To have a knowledge of the distribution of craters over the whole surface of the Moon would be of the greatest help to the astronomer who grapples with the problem of the origin of the craters. Other questions which could be answered from a study of photographs would be the distribution of maria (the dark areas) and of ray-craters over the whole surface, and the orientation of rilles (vast trench-like features) and linear ridges.

The technical problems which would be involved in sending a fully-equipped probe vehicle around the Moon and in recovering information from it are, even to-day, of extreme difficulty, and the expense would be immense, but, with the recent demonstration of the great skill of the Russian and American rocket engineers, and with the inevitable advent of improved techniques, one is hopeful of eventual success.

Probably the most useful single experiment—always with the proviso that the records could be recovered—would involve straight-forward photography. A single photograph could be made to record a large area of the lunar surface. Comparison photographs taken in violet and red light may be used to provide a delicate test for the presence of a lunar atmosphere. (No trace of any gas has been detected so far.)

In principle no more expensive than the circum-lunar probe vehicle, as far as propellant requirements go, would be a vehicle which was designed to crash-land on the earthwardly-turned face of the Moon.

Such an operation might seem to be simple enough if the vehicle could be accelerated up to escape velocity and pointed in the right direction, but J. G. Porter and others have pointed out that, in actual fact, both the direction of motion in space, and the velocity of the rocket during the initial part of the trajectory would have to be dictated to within impracticably narrow limits if the vehicle were to hit the Moon or to go round it and eventually return to the Earth. Furthermore, to hit a given part of the Moon would be virtually impossible without some sort of remote control guidance. Such control would, of course, demand extra initial weight and would complicate matters considerably; hence, such a scheme must retreat even further into the future.



DR. GILBERT FIELDER

What would be the value of such an experiment? Two suggestions which have been advanced are that the crashed rocket should liberate a quantity of dye, so that this would mark its position and be visible from the Earth, and that the rocket should contain an explosive payload to be fired automatically at the instant of impact to produce a crater in the Moon's rocks. There would be a considerable risk attached to the success of the first-mentioned experiment, for whether or not the coloured patch would be visible would depend, for one thing, on the relative sizes of the two sets of mingling particles. For instance, if there *were* a very fine dust of appreciable depth covering the area where the dye was to be distributed (presumably by means of an explosion) then dye-particles would tend to disappear beneath the dust. In any case, a very large volume of such a dye

would have to be carried by the rocket, and the experiment would hardly seem to be worth while.

A special form of nuclear bomb, exploded in a convenient position on the surface of the Moon, could probably be made to produce an observable crater. A subsequent evaluation of the form of a large crater would be of great interest, since it is still uncertain how the majority of the lunar craters were produced. However, a little thought will show how difficult it would be to glean such information. A crater five miles in diameter could be measured fairly easily, but the cost of producing such a large crater at any position on the Moon would be enormous. If the position were to be previously selected, then the problem of very accurate control would again become even more intimately involved with the other difficulties of the experiment.

Why go to the Moon to perform this experiment? In fact, no one would wish to produce very large craters in any of the deserts of the Earth by means of nuclear weapons, because of the highly undesirable effects associated with these sources of energy; the Moon, it has been said, would act as an ideal testing ground. The astronomer hopes that tests would be made with the purpose of increasing our knowledge of the Moon, rather than that of the bombs!

It seems that one must return to the idea of sending a rocket, possibly guided, on a journey around the Moon. Photographs could be taken automatically, but such records, would, of course, be useless unless recovery were possible. Since the attraction of the Moon would modify the orbit of the rocket, and the minimum distance of approach of a guided rocket could not be estimated accurately beforehand, it would be difficult, in practice, to predict the actual path of return of the rocket vehicle unless observations of the position were made fairly regularly during its flight. Even then, could the photographs be released? Would there be any chance of our recovering them?

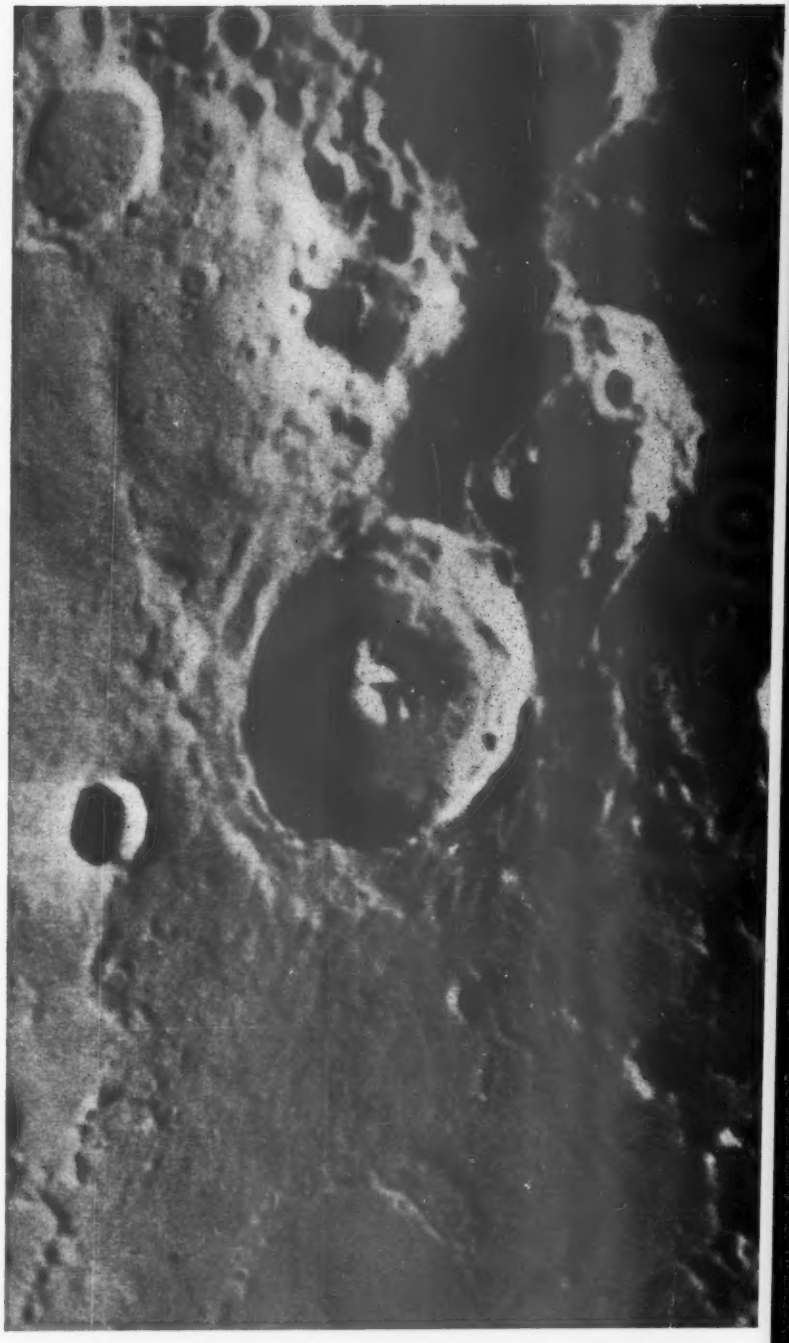
The difficulties of such an operation would be overwhelming, and it seems that, if we were to get our information back, it would have to be transmitted by radio-waves, straight from the rocket.

This would be possible on certain wave-lengths, but no reception would be obtained whilst the rocket was out of sight behind the Moon. Hence, if pictures of the far side of the Moon were to be recorded, the rocket would not have to pass too closely to the Moon. One difficulty would be to direct the camera at the Moon.

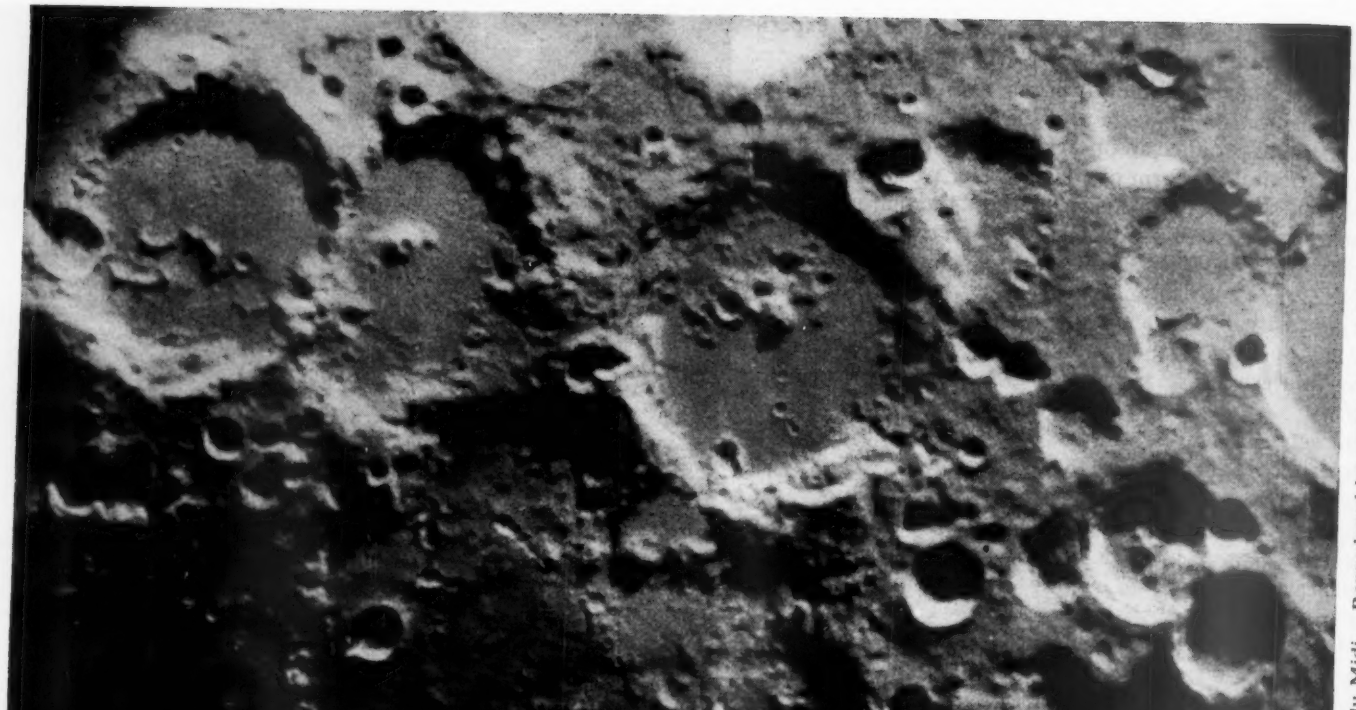
A simultaneous experiment, which would probably yield a negative result, could be performed to investigate the presence of a lunar ionosphere. In this experiment, the time which the rocket spent out of sight behind the Moon would have to be compared with the period of no-reception of the radio-signals.

Many other experiments could be devised. Thermal, polarization, and spectral measurements could, in principle, be collected by means of one probe-rocket, the data could be converted into radio frequencies, and, after reception at laboratories on the Earth, reconverted into the original signals.

These data, admittedly, would primarily interest the scientist, but it is likely that the new information would have an impact not only upon science, but upon humanity in general.



The lunar crater Theophilus. Photo by Kopal, Ring and Fielder, Pic du Midi. *Reproduced by permission of Dr. J. Rösch*



Parts of the Southern Hemisphere of the Moon. Photographs by G. Fielder. Pic du Midi. Reproduced by permission of Dr. J. Rösch

Space-stations—To Be or Not To Be?

By H. E. ROSS

Much discussion has recently taken place as to whether manned space-stations, moving round the Earth far above the atmosphere, will have to be built before interplanetary voyages can take place. H. E. Ross, well known for his pioneer work upon this problem, sums up the pros and cons.

Some people say that large and permanently manned artificial satellites could provide so many services that they must be built. It is even asserted that interplanetary flight is impossible without them. Other people are however equally certain that space-stations would be a waste of time and money. . . . If the reader will endure recapitulation of some points probably well known to him, I will attempt an impartial and perhaps overdue appraisal of the merits of the contending claims.

To begin with, it should be remembered that there is a vast difference between the initial weight of "hardware" needed to establish a car-size sputnik in an orbit and that needed to project hundreds of tons of constructional parts and gear, let alone muster them for assembly and transport men into space and get them back.

The magnitude of such a task, the building of a fully-fledged space-station, will be realized if I quote von Braun's estimate for the space-station he has proposed for an orbit at 1,075 miles above Earth's surface. His figures are:—36·5 tons of useful payload delivered to the orbit by a three-stage rocket which at launch from Earth weighs 7,000 tons, the completed station to weigh over 400 tons.

Although von Braun obviously believes that a terrestrially-launched rocket as heavy as a cruiser is a prospective engineering practicability, it is manifest that a much better final to initial weight ratio must ultimately be achieved, even though the winged top step of von Braun's monstrous rocket would be capable of returning from the orbit.

But I must confess that 7,000-ton space-ships appal me. They especially appal me if manned astronautical ventures *begin* with vehicles of this magnitude, as we have seen is being suggested.

No—if space-stations and interplanetary flight are to fulfil astronautical prophecy, then in my opinion much more potent fuels, much more competent motors, much more margin for error, much more "go-up" and much less "blow-up", and altogether much less derring-do must encompass the enterprises. In short, far better rockets in every respect than have been produced . . . or, with all due deference and respect to the Russians, are likely to be available for some considerable time. The reader is of course entitled to his own opinion as to what will ultimately be possible, but for my part I am going to assume that the time will come when space-stations *can* be built. For one thing, I hold that opinion: for another, this article cannot end here. . . . In fact there is a great deal more to discuss.

I think it may be taken for granted that if a space-station can be built it can be maintained. But compared with robot satellites its construction would be very costly, and it would be expensive to sustain, even with standardized and fully productionalized space-ships.

The question therefore arises as to whether a space-station is an economic proposition—especially in the face of opinion that a few relatively cheap robot satellites could furnish all the really important services envisaged for a manned station.

Now, if present *un*-reliability of engineering and electronic gear were the only criterion, then a manned space-station would be not only economically justifiable but absolutely imperative. It would be quite beyond the world's assignable manpower to make and project enough rockets to replace the sputniks as they became phutniks.

On the other hand, it is reasonable to assume that the time will come when a solar or atomically powered robot satellite could be relied upon to remain operative for several decades. However, it is impossible to foretell whether such reliability will be obtained before or after the building of a permanently manned satellite can be undertaken.

Another relevant consideration is, that whilst robot satellites demand physical replacement in event of breakdown, a space-station must be provided with fresh personnel and consumable stores every few weeks or months. This will entail use of very big ships; at least as large as those wanted for the projection of robot satellites. Moreover, manned satellites involve the hazarding of human life.

We may then conclude that if a robot satellite *is* reliable *and* functionally as competent as a space-station, then robot satellites are, in the long run, likely to be more economic than a space-station—even if several of the former must be established to equal the versatility of each manned version.

But it has been claimed that manned satellites can perform certain functions not possible with robot satellites. If true, this might be a decisive factor in favour of space-stations, at any rate as supplementary utilities . . . . Let us, then, discuss these specialities.

From the very early days of astronautical history, it was visualized that a space-station could be used as

Parts of the Southern Hemisphere of the Moon. Photographs by G. Fielder, Pic du Midi. Reproduced by permission of Dr. J. Rösch

a rendezvous for personnel and depôt for the fuel, stores and gear needed for flights to the Moon and planets. This idea arose because any practical interplanetary vessel powered by "conventional propellants" would run out of fuel long before it had completed a round-trip to the Moon. About the best that could be done was a round-trip to an orbit close to the Earth. However, if fuel at least could be accumulated at an orbital terminal, brought there by several vehicles, then a comparatively small space-ship arriving nearly empty could refuel for its voyage to another heavenly body. And it could again refuel on its return to the terrestrial stand-off orbit, thus enabling it to employ rocket braking during its descent to Earth.

Although the imperative need for "orbital refuelling" may not always exist, owing to the predictable development of far more potent fuels and motors than we now possess, yet it is perhaps true to say that, all things taken into account, it may remain the most *convenient* way of crossing space. It may be necessary to have one type of vehicle for the initial ascent and final return to Earth and another radically different type for the actual planet-to-planet transits. It may even be necessary to build the long range ships in the terminal orbit; in which case a space-station could be used as a workshop and living quarters for the assembly and maintenance personnel.

We can then conclude that, on present-day outlook, one or more space-station "terminals" will ultimately be desirable. On the other hand, elaborate hotels-cum-storehouses are certainly not *initially* essential. Freighter rockets, either robots mustering automatically or by telecontrol, or manned versions with detachable cargo sections, would suffice to furnish a supply of fuel and stores in space. If, however, a terminal in space is needed for other reasons, then the station *could* also be used to hold fuel and other requisites.

But let me make this clear: there is nothing in the preceding discussions to indicate that a space-station is indispensable to the accomplishment of manned interplanetary flight. In fact this would be true only if we could foresee no further advance in the science of reaction propulsion. And that, most definitely, is not the case.

The military usefulness of a space-station as a missile launching base may next be considered. It has been claimed that the station would be virtually invulnerable to attack either by guided missiles launched from the surface of the Earth or fired from manned space-ships sent up to attack from relatively close quarters. It is argued that, in the first place, a sufficiently accurate guiding mechanism would probably be too heavy and bulky to be installed aboard an unmanned missile. As regards the second case, it is said that the station would certainly be larger than the attacking vehicle, and so possess better fire control equipment, whilst its missiles could be bigger and of longer range.

For my part, I think the first argument takes far too mean a view of the prospective compactness of guidance gear and likely accuracy of future telecontrolled or robot homing missiles. The military demand for great accuracy exists, and I feel sure can and will be met. Besides, astronautically, accurate guidance is needed for mustering constructional materials and supplies in various orbits. Indeed, if robot rockets cannot be made to programme their flights accurately, with little or no remote monitoring, then interplanetary surveys must depend entirely upon manned ventures, which is most undesirable.

Nor is this all that can be said about the vulnerability of a space-station. In an attack by manned missile-armed spaceships one thing at least seems obvious—the station would be liable to run out of ammunition before the Earth-based attacker did.

In any case it has been pointed out by Professor L. H. Thomas that a space-station could be destroyed without attacking it directly. The proposal here is to send up rockets into the same orbit but travelling in the opposite direction, and then burst them. As a result, the station would repeatedly run into a cloud of highly destructive objects, and it would do so with an impact velocity of twice its own orbital speed. So, unless heavily mailed, the station would, after a few revolutions, finally expire in a rash of explosive decompression.

Another function suggested for a space-station is its employment by a "genuinely peace loving country" (whatever that means) or the United Nations, as a guardian angel equipped with powerful optical and radarscope aids and charged with the duty of spotting and reporting warlike preparations in any part of the world. It is claimed that large-scale deployments of armour, troops, warships and planes could be detected, and rocket launching sites kept under surveillance for abnormal activity.

Before going any further, it must be pointed out that statements have appeared in the Press to the effect that the U.S. Air Force is *already* contemplating not only T.V. equipped reconnaissance satellites but also manned "space-platforms". One may be permitted some hilarity over a report that Atlas rockets are proposed for provisioning the latter, for their payload would be ridiculously inadequate, even with powerful initial boost. However, it can scarcely be doubted that evaluations of such schemes are being made. Nevertheless, and apart from the political dynamite these *Big Brother* plans contain, I question their value as gleaners of military information. I do not dispute that space vehicles could spot mass military movements, but it seems to me probable that such formations will in future constitute the "mopping-up" stage of war, not as hitherto the initial phase.

We are indeed verging on the time when an overwhelming rocket offensive could be opened at a moment's notice, without detectable preparation. The observers in a space-station might know where all the rocket launching sites are located, but it seems only common sense to suppose that very little would show above ground, and that whatever cannot be concealed would be so well camouflaged as to make it impossible to tell

which launchers have been loaded from long-established stocks of missiles. Nor would it be possible for a space-station to know precisely when and precisely where in all the seven oceans rocket-armed submarines will bob up and open fire. It should also be remembered that a single space-station could not see all the world at once, and so might easily remain ignorant too long of the military action it is supposed to forewarn. For the rest—well I leave the reader to estimate how many space-stations would be needed to provide a sufficiently minute view of all the Earth's surface all the time, and to decide whether that number is justifiable . . . or just simply preposterous.

However, I think that in any case we must conclude that space-stations, owing to their inability to see a button, would not be able to give adequate warning of rocket attack.

Let us now consider a space-station in the rôle of retaliator or aggressor. It might be an arsenal from which H-headed rockets are dispatched against terrestrial targets; it might similarly control a fleet of orbiting rockets; or it could control the launching of Earth-based missiles.

Apart from these proposals there remains the "Sun-Gun"—that is, a giant mirror, or network of mirrors, used to collect sunlight and focus it at will on parts of the Earth, with incendiary intent. However, to be effective, such a device would have to be at least several square miles in area. I therefore propose to omit further discussion of this proposal and confine my remarks to the "conventional" type of space-station.

Now, if the missiles were stored *in* the space-station they could be serviced and readied at will, *and it would not be possible to prevent them being launched.* Unless, indeed, the station is "Pearl-Harboured" out of action. On the other hand, unless the station's missiles are robots using celestial guidance and programming their own trajectories, they would be susceptible to interference (for example, radio jamming or capture): they might indeed be turned against either the station itself or its terrestrial owners! Moreover, a space-station's stock of missiles would be small and probably difficult to replenish once hostilities had begun.

If, however, the station controls a fleet of freely orbiting rockets, then an unlimited number of missiles is theoretically possible. On the other hand, it seems improbable that such a menace would be tolerated, even in the guise of a "deterrent" and under the ægis of the United Nations. But in any case there is the grave practical difficulty of keeping a large fleet of freely orbiting rockets ready for action at a moment's notice, especially if liquid propellants are used. Manned tenders would be needed for servicing and final preparation. And because of the risk of firing signals being jammed, these tenders must be near—indeed, preferably physically linked with—the rockets which they are about to fire.

However, let us suppose that all these objections have been overcome. The question which then presents itself is: who authorizes the pressing of the button?

Before answering that question, let us remember that effective counter-measures may have to be taken within minutes—very likely too soon for governmental consent to be got. Let us also remember that, according to newspaper reports, nuclear bombers have *already* flown towards their targets because radar sightings have been misinterpreted. We are then indeed forced to the conclusion that the Third World War might be precipitated on the spur of the moment and on dubious evidence . . . *by one man.* It is also apparent that a space-station controlled by one country would not diminish the danger of our present position but would increase it.

However, let us assume that the space-station is controlled by the United Nations. In this case we may perhaps suppose that consultation will be required before the space-station is permitted to act.

But how long will it be before agreement is reached? . . . I submit that the answer is: certainly too long to forestall a major attack, and much more likely—never. Remember—*all* nations *always* and under *all* circumstances claim to be "peace loving". They never arm for anything but "defence". It is indeed ludicrous to suppose that a belligerent member nation would admit aggression and agree to being bombarded. And since the suspected country must be asked whether the allegation is true it will know that its intention has been detected; will deny the accusation in order to gain time; and long before U.N.O. formally reaches a decision, will press its *own* button.... In short, if a space-station is really dangerous it cannot be left in the hands of one nation; and if it is commanded by a league, such as the United Nations, then it will never get into action soon enough to be effective.

Now take the case of a space-station commanding Earth-based missiles. The objections already stated apply but the following additional remarks may be made. There would obviously be no difficulty about servicing and readying the missiles, and huge numbers and many varieties might be controlled. Moreover, the trouble, danger and cost of raising the missiles into an orbit (or, be it noted, to the Moon) is avoided. On the other hand, risk of jamming and perhaps radio capture remains.

Two main points emerge from the preceding discussions: (1) it cannot be guaranteed that a space-station will be able to fire missiles under its jurisdiction unless its personnel have access to the weapons; (2) the strategically best and cheapest base for rocket missiles is the Earth itself.

There is a third point: war must be eliminated before it eliminates *us.*

We now come to the paradoxical contention that the best place for a space-station is on the Moon!

It would certainly seem true that some functions proposed for a space-station could be fulfilled equally well, or better, on the Moon . . . *when it is possible to have a permanent base there.* For one thing, a lunar observatory for solar, planetary, stellar and galactic studies would not need to be gyro-stabilized. It could also be visited without the "space-taxis" visualized by

von Braun for his independent and semi-automatic, remote-controlled orbital observatory. On the other hand, if the observatory is part of the space-station itself it can be visited as frequently as desired without much trouble or risk. Obviously, even an elaborate station would be cheaper to establish and maintain than a lunar base; on the other hand, its usefulness would be of a more specialized nature. These further pros and cons deserve attention.

An astronomical observatory on the Moon could of course be used for telescopic meteorological study of the sunlit terrestrial hemisphere, virtually the whole surface of our globe rotating into view every 24 hours. But manned or robot or telecontrolled space-stations close to the Earth in polar orbits would possess the extra advantage that *nocturnal* observations of cloud-patterns and movements could, at this range, be made by means of electronic devices.

Although the main facts about meteors and cosmic rays as hazards to extra-terrestrial vehicles and men will be known in the near future, I think that statistical studies at least will continue indefinitely, in free space near the Earth, on the Moon, and further afield *ad infinitum*. Much of this work could be done with instrument rockets traversing long elliptical orbits or revolving in virtually circular ones; however, in the case of cosmic rays the presence of human beings as manipulators of biological research is highly desirable, and as *themselves* subjects of experiment obviously imperative. These, then, are the reasons why cosmic ray research is usually included in the functions proposed for a space-station. The disputation nevertheless remains that this work could be done equally well on the Moon.

So far as cosmic rays research is concerned, I think this is largely if not wholly true. But which comes first? . . . a space-station or a base on the Moon? I for one do not know, and therefore cannot uphold or deny the contention. I can only say that if a space-station exists I feel sure it will be used for cosmic ray research.

This leaves us with a similar statement about meteors—that they would be just as well or better studied on the Moon.

Here one thing at least is certain: the armouring needed by spaceships and space-stations against meteors will have been determined by non-manned probe vehicles before human beings are exposed to the risks. Such studies have in fact begun. It is also obvious that, sooner or later, a space-station or far-flying spaceship will be hit by a meteor large enough and fast enough to seriously damage plant or one of the isolatable compartments. On the other hand, a voyage to the Moon entails only 5 days exposure to meteors, and by scheduling transits for times of low meteor incidence the peril can be minimized. And a base on the Moon can be underground and quite secure from meteor damage, whilst at tne same time affording adequate opportunity for instrumented and telecontrolled study of meteoric bombardment of the surface, excursions abroad on the satellite being made, if necessary, in heavily mailed vehicles.

We may then conclude that the Moon could be safer than a space-station (or spaceship) as regards meteors. We may I think also conclude that if a space-station exists meteors *will* be studied for the simple and sufficient reason that they will themselves insist upon it!

Physiological experiments with animals and men under conditions of zero gravity are being made, using sounding rockets and aircraft. But except in the classic case of Laika, the Russian Sputnik II dog, the periods of exposure to zero gravity have, at the time of writing, been brief. By the time the establishment of a space-station becomes possible, much more will be known, including tests with manned vehicles orbiting for long periods. However, even when we are satisfied that men can exist *and* work indefinitely under zero-gravity, a great deal remains to be learnt about the effects of sub-normal and zero-gravity on, for example, the growth and procreation of simple organisms, plants and creatures.

Much of this research requires at least the occasional presence of a human manipulator, which rules out use of instrumented satellites for the more complex experiments. In short, a space-station is required, though not necessarily a very elaborate one. It could be simply an orbiting manned rocket capable of return to Earth. Various degrees of subnormal gravity down to zero could be obtained by rotating the vessel at different speeds or stopping rotation. But for very protracted research a highly elaborate space-station is essential. . . . Would it then be better to wait until such experiments can be done on the Moon? My reply is that experiments with one-sixth gravity and upwards could be done on the Moon, by using its natural gravity and boosting by centrifuging; but a space-station or spaceship are the only places where experiments with *less* than one-sixth gravity can be done—at any rate till Phobos and Deimos become available to us.

This brings us to my last item of the present discussion—orbital radio repeaters. As Clarke originally pointed out, only three such satellites would be needed to provide global coverage if they are spaced 120° apart in the 24-hour west-east equatorial orbit, where at 22,000 miles altitude they would keep pace with Earth's axial rotation and so remain virtually stationary in the sky.

All kinds of terrestrial radio communication—commercial telegraphy, sound and television broadcasting—would unquestionably benefit enormously if these satellites existed. The reliability and range of short wave transmitters would be vastly increased and fewer of them would be required. These advantages are however offset by the high initial cost of establishing the orbital relays and high replacement or maintenance expenditure. If *manned* stations are used, then breakdowns will be negligible but large and costly rocket ships will be needed to change personnel every few weeks or months and transport a variety of consumable stores. If robot units are used, then equipment reliability is the factor controlling expense, for even a minor breakdown

[*Continued on page 316*

Cosmic Boomerang

By G. CHEBOTAREV, translated by Ivan Delay

In this article Dr. Chebotarev, Russian mathematician and physicist, describes some Soviet views upon recent experiments.

What are the basic practical difficulties hindering the realization of interplanetary flight in our time? Utilizing existing kinds of chemical fuel it seems possible to hurl an apparatus into cosmic space with the required speed if only, in this case, the weight of the apparatus does not exceed a few kilogrammes!

Meanwhile, if we want to send a space-ship on a prolonged journey which, according to our desire, would approach various heavenly bodies, photograph them and even make a film-survey of their surface, carry out astrophysical observations with the aid of automatic devices and later return to Earth—it is necessary to provide such a space-ship with sufficient reserves of fuel for manœuvring. The total weight of this fuel (even though there will be no people in the rocket) will be hundreds, perhaps thousands and tens of thousands of tons, subject to the complexity of the route selected. Modern technique is unable to throw a space-ship of such weight into the cosmos.

Thus, one would think there is an insoluble contradiction between the possibilities of technique and the necessary conditions of the task.

However, this is not so. A way out can be found.

In Leningrad, on one of the quiet streets of Vasilevsky island, a small two-storeyed building houses the Institute of Theoretical Astronomy of the U.S.S.R. Academy of Sciences. It is the only specialized institute in the world whose tasks are the detailed study of the movements of heavenly bodies.

With the aid of vast automatic computing machines calculations on the movements of the Earth, Moon, other planets of our Solar System and also the Sun and the largest and brightest stars in space are being conducted in the institute. On the basis of these calculations special astronomical calendars (called "Astronomical Ephemerides") are published, whereby one can easily determine the position of these heavenly bodies on any day and hour of a given year.

But what does an interplanetary ship travelling into cosmic space represent? From the viewpoint of astronomy: an ordinary heavenly body fully subject to the law of gravitation.

And here a new conception emerges. Are the methods of heavenly mechanics necessary to calculate such a trajectory of interplanetary flight according to which a moving space-ship would approach the Moon to a sufficiently close distance, skirt it and afterwards return to Earth again?

As the movement of the interplanetary ship is, in this case, under the influence of attraction from various heavenly bodies, fuel is needed only at the moment of starting in order to give the ship a cosmic speed of 11 kilometres per second. This speed, as we know, is necessary in order to overcome gravity and "escape" from the Earth. According to calculations worked out about 16 tons of fuel in all are needed for this. Calculations show that the rocket itself (without the fuel)—i.e., the apparatus and instruments with all-over visibility enclosed in a round shell—will weigh 50-100 kilogrammes.

The first trajectory of such a model, which was successfully calculated in the Institute of Theoretical Astronomy, allows the space-ship, after 5 days, to approach the Moon's surface to a distance less than 30,000 kilometres and return afterwards to the Earth. During the flight the greatest distance that the rocket will reach from Earth will be 416,000 kilometres, though the distance from the Earth to the Moon is 384,000 kilometres. This gives the rocket a chance to skirt the Moon and, as the speed of the ship has decreased to almost zero during this time, the rocket remains near the Moon for over two days exploring the lunar hemisphere (not seen from the Earth) with the aid of automatic equipment.

The return flight to Earth will also continue for about five days; due to the influence of the Earth's attraction the speed of the ship gradually increases and at the moment the rocket enters the region of the atmosphere its speed will again reach 11 k.p.s.

A safe descent to Earth surface at such speed is a difficult technical task. However, as far as the density of the Earth's atmosphere gradually increases, it is possible, with the aid of a special parachute or gliding mechanism to safely land the rocket together with the automatic devices placed in it.

How clearly can one imagine the flight of a rocket on its trajectory without fuel?

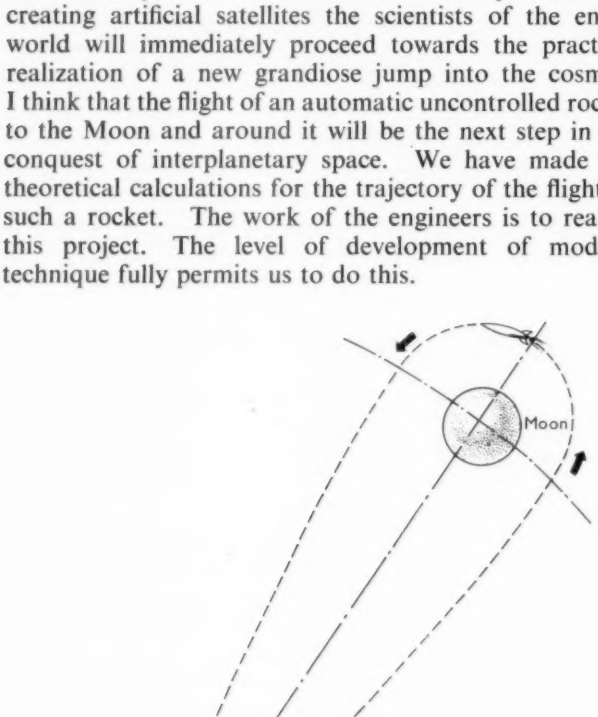
Altogether it is simpler to liken the rocket to the boomerang. It is well known that this original implement has a habit of returning to the person throwing it. Roughly, the very same will happen to our rocket. The rocket "thrown" with great force into space will reach as far as the Moon, even higher, or fly to orbit the Moon, skirt it and return to Earth. The resemblance of this rocket to the boomerang, one understands, is purely superficial. It will move subject to the operation of the forces of attraction according to the law of a freely thrown body. And in this sense our rocket will resemble an ordinary stone thrown vertically upwards.

It is known that the initial speed of a stone at Earth surface decreases to an extent and at a point becomes

equal to zero. Afterwards the stone begins to fall and at Earth surface again reaches the greatest speed. But in this the stone moves only by the force of the Earth's attraction. As you know, we cannot throw it very far. But the force of attraction of Moon and Sun will also exert an influence on the rocket which will move over vast distances into interplanetary space.

The flight of people in such a space-ship is, of course, impossible; in this case, even with the absence of fuel supplies, the necessary weight of the ship again increases greatly. But it is fully possible to send some living creature (for example a mouse or guinea-pig) on this interplanetary journey.

The realization of the interplanetary flight of an uncontrolled device of small weight described here is, in principle, only a little more complicated than the launching of an artificial Earth satellite. Such launchings were carried out in 1957-58 during the Geophysical Year. Undoubtedly, after the solution of the problem for creating artificial satellites the scientists of the entire world will immediately proceed towards the practical realization of a new grandiose jump into the cosmos. I think that the flight of an automatic uncontrolled rocket to the Moon and around it will be the next step in the conquest of interplanetary space. We have made the theoretical calculations for the trajectory of the flight of such a rocket. The work of the engineers is to realize this project. The level of development of modern technique fully permits us to do this.



(Illustration—from an original by A. Sysoyev)

An uncontrolled rocket, like a boomerang, can be "thrown" into cosmic space. It will reach the Moon, fly around it and return to Earth.

Already, at the present time, it is completely obvious that one can calculate the flight of an uncontrolled interplanetary ship, according to a more complex trajectory, without the expenditure of fuel on the journey: for example, to the planet Mars with a return to Earth. And now we are conducting calculations for determining the orbits for the flight of a rocket around Mars, although, undoubtedly, this problem is more complex. In a flight to Mars we are compelled to take into account the attraction not only of the Earth, Moon, Sun and Mars, but possibly of Venus and Mercury. And every new heavenly body greatly complicates astronomical calculations. Landing on the Martian surface is, of course, quite excluded, as the descent on to the planet and return ascent would need great quantities of fuel supplies.

NEW SWEDISH JOURNAL

The Svenska Interplanetariska Sällskapet (Swedish Astronautical Society) has produced a new periodical entitled *Astronautik*. Vol. 1, No. 1, consisting of 52 pages, is excellently produced. Though most of it is—naturally!—in Swedish, there is a long paper by C. J. Clemedson, "Some Biophysical and Medical Problems Involved in Manned Space Flight", which is printed in English.

It is clear that the whole periodical is of a very high standard, and it is a welcome addition to astronautical literature. Our Swedish colleagues deserve all congratulations; we wish *Astronautik* every success.

THE EDITOR

Continued from page 314]

may put the satellite permanently out of action, with disastrous interruption of terrestrial communications until another unit has been shot into position. Duplication of the satellite's plant, gear and circuitry, with automatic switching in event of breakdown, would of course improve reliability, but there is a practical limit to such precautions.

* * * * * *

I have now covered most of the pros and cons of space-stations, and where possible have stated my opinions as to the feasibility and utility of the proposed function. In some cases, however, it is impossible—or at least most rash—to judge the worth-whileness at present. We are not yet far enough ahead with astronautics to decide all the issues dealt with in this article. Nevertheless, I am prepared to summarize my view to the extent of saying that whilst no *one* function may justify the establishment of manned space-stations, yet the inclusion of *several* functions may render them indispensable.

Astronautical Societies of the World—2.

ELLINIKI ASTRONAFTIKI ETAIRIA
(Hellenic Astronautical Society)

By Eng. ELIE N. PETROPOULOS, Secretary General

The Hellenic Astronautical Society was founded on December 9, 1957, in a meeting held in Athens in which engineers, astronomers, economists, chemists, technicians, physicians and mathematicians took part. At the meeting, the constitution of the Society was adopted, further procedure for the approval of Constitution by the relevant State Authority having been entrusted to a six members' provisional acting committee. After completion of formalities, the Society being legally established, a General Meeting was convoked in which election took place, the Council of Administration for 1958 having been elected (see below).

It is of interest to be stated that the foundation of the Hellenic Astronautical Society was welcomed by the international astronautical circles, a fact which proves the tight solidarity of astronautical societies. Heartily greeting messages were thus sent by the President of International Astronautical Federation, Mr. Andrew Haley; the Danish Interplanetary Society through its President, Mr. Leo Hansen; the prominent technician, Dr. Eugen Sänger; the American Rocket Society; the Interplanetary Society of Chile; etc.

Aims of the H.A.S. are as follows:—

1. The study and research (theoretical and practical) of the problems of space.
2. Polularization of contemporaneous progresses of Astronautics.
3. Co-operation with the International Astronautical Federation and Astronautical Societies throughout the world.
4. Acquisition of a Planetarium and its installation in Athens, for an easy performance of the polularization of knowledge in Astronomy and Astronautics.

Council of Administration is as follows:—

President: Stavros Plakidis, Director of the National Observatory of Athens.

Vice-President: Constantine Exarchakos, Major-General of Air Forces.

Secretary General: Elie Petropoulos, Civil Engineer.

Acting Secretary General: Fotis Karapiperis, Lecturer at the Athens University.

Curator: John Frangos, Professor in the Graduate School of Industrial Studies.

Treasurer: John Papanicolaou, Director in the Ministry of Finance.

ELIE PETROPOULOS
Civil Engineer, General Secretary of Hellenic Astronautical Society (H.A.S.), Athens, Greece

Directors:

Basil Frangoulis, Professor in the Athens Polytechnic School.

Gerassimos Galiatsatos, Graduate Mechanical-Electrician Engineer.

John Argyrakos, Professor in the Athens Polytechnic School.

Patroclos Yangou, Aircraft-Builder, Professor in Aviation School.

Address of Secretary General of the H.A.S. is as follows:—

Ministry of Communication and Public Works, Constitution Square, Athens, Greece.

Correspondence

SIR,—One frequently hears it said that the first spaceships must have a re-entry capability; the idea being that the crew would go into space, spend a short time there and then return. I would like to make an alternate proposal which may considerably simplefy the design of the first ship. It is to design a vehicle which could carry one man into space; but which would not be able to return. A number of these vehicles would be manufactured; and with them freight would be sent to a low altitude orbit. After sufficient freight has been sent, and the reliability of the vehicle is proven, a man would be sent. He would rendezvous with the freighters and assemble living quarters. More people and freight would similarly be sent; and the first space station would thereby be established.

Since some of the people who go into space may change their minds about the desirability of spending their lives in space, some re-entry system is needed. However, such a system need not be developed initially. Instead, every effort should be made to put space travel on a sound financial basis; and then when sufficient money and knowledge are available, a re-entry system would be developed. All that this means for a person going into space is that he must "sign up" for several years in space.

Using this approach, the capital investment needed to establish the first space station can be considerably reduced. For one thing, the payload of the first ship can be much smaller if it is devoid of wings and other re-entry equipment. The launching vehicle can therefore be much cheaper both to engineer and to manufacture. Furthermore, with this plan, the extensive research programmes needed to develop a re-entry system could be postponed. Also, of course, since it costs a great deal to send a man into space, it is economically desirable to leave him there to do some good rather than to bring him back immediately.

Greater safety of personnel would also be possible with this plan. With a cheaper launching vehicle, more unmanned shots could be made; making it possible to remove any bugs. Also, by postponing development of a re-entry system, more advanced technologies could be used in its design, so greater safety margins would be possible. Furthermore, since some people will not wish to return, they need not be subjected to the uncertainities of re-entry.

Yours, etc.,

ED. MIKSCH.

264, N. Pleasant Street,
Amherst, Mass., U.S.A.

SIR,—All astronautical books state that the first and second major planets on which Man will set up scientific outposts will be Mars and Venus, respectively. However, it seems that the writers do not consider that it would be possible to set up outposts on any of the other planets because of their unusual surface conditions, or that they would be of any scientific value.

A solar observatory on Mercury would be extremely valuable because—Mercury has very little or no atmosphere, and therefore a great deal of the ultra-violet part of the solar spectrum could be studied; the Sun would appear to be three times greater in diameter, and nine times brighter, than it appears to be as seen from Earth, and consequently more detail would be visible and more powerful spectroscopes, etc., could be used; and thirdly, Mercury keeps the same side permanently turned towards the Sun, and therefore sunspots, prominences, etc., could be observed without interruption over periods of several weeks or more.

It would be necessary to establish the observatory on the "day"-side of the planet near one of the poles, since the temperature at the Equator rises to over 700° F., and, as the temperature at the poles is much more moderate, it should prove no more difficult to survive there than to survive on the Moon during the lunar day.

I would be very interested to know the views of any of your readers on the possibilities of a solar observatory on Mercury.

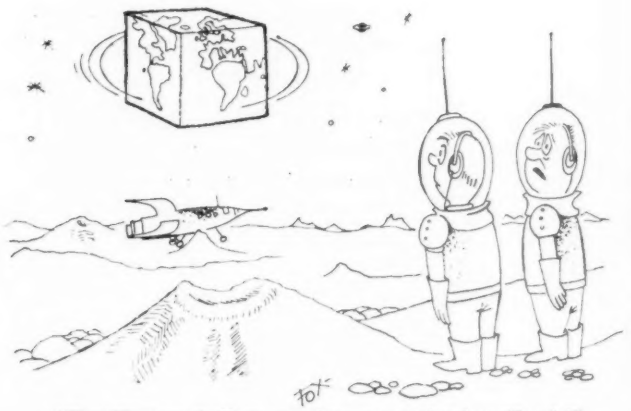
Yours, etc.,

M. J. PRICE.

40, Fairhaven Road,
Redhill, Surrey.
April 14, 1958.

A Look into the Future

On August 19, 1958, Professor H. S. W. Massey, F.R.S., Quain Professor of Physics at the University of London, and a member of the National Institute for Research in Nuclear Science, made an interesting comment during a broadcast Press Conference, in which he was being questioned by an amateur astronomer, Patrick Moore, and two journalists. Professor Massey pointed out that in the future, when there are many small test vehicles orbiting the Earth, there will be a danger of such vehicles becoming a mild nuisance by causing radar echoes which will interfere with certain types of experiment. At the moment, when only a few test vehicles are in orbit, the problem does not arise; but it may well have to be taken into account by—say—1970. W. N.



"They'll never believe us when we get back to Earth!"

Reproduced by courtesy of the Rhine Gazette

TABLE OF ARTIFICIAL SATELLITES

Some details about the Earth satellites successfully launched, up to August 10, 1958

Name	Launch date and lifetime	Shape and weight	Size	Date	Orbital inclination (deg.)	Orbital period (min.)	Perigee height (n.m.)	Apogee height (n.m.)	Orbital eccentricity	Angle from Apex to Perigee (deg.)
Sputnik 1 .. 1957α2 instrumented sphere	1957 Oct. 4.90 ? 92 days	Sphere 184 lb.	23 in. dia.	1957 Oct. 4·90 1957 Oct. 25·8	65 65	96·2 95·4	122	512	0·052	−39
Sputnik 1 .. 1957α1 rocket	1957 Oct. 4.90 57·1 days	Cylinder? —	—	1957 Oct. 4·90 1957 Nov. 19·00	65 65	96·2 92·0	122	512	0·052	−39
Sputnik 2 .. 1957β	1957 Nov. 3.19 161·9 days	— —	—	1957 Nov. 4·00 1958 Jan. 4.00 1958 Feb. 21.00 1958 Mar. 25.00 1958 April 9.00	65·33 65·29 65·26 65·23 65·21	103·760 100·505 97·105 93·785 90·780	122 119 114 107 97	902 739 570 402 253	0·0987 0·0802 0·0605 0·0400 0·0214	−31 −55 −76 −91 −98
Explorer 1 .. 1958α	1958 Feb. 1.16 4 years	Cylinder 30·8 lb.	80 in. long 6 in. dia.	1958 Feb. 1.16 1958 July 10.05	33·2 33·2	114·8 113·5	199 192	1,371 1,318	0·139 0·134	31 33
Vanguard 1 .. 1958β2 instrumented sphere	1958 Mar. 17.5 200 years?	Sphere 3¼ lb.	6·4 in. dia.	1958 Mar. 17.5 1958 June 19.52	34·3 34·3	134·1 134·1	353 353	2,140 2,136	0·191 0·190	— 92
Vanguard 1 .. 1958β1 rocket	1958 Mar. 17.5 —	Cylinder 50 lb.	4 ft. long 20 in. dia.	1958 Mar. 17.5	34·3	134·1	353	2,140	0·191	—
Explorer 3 .. 1958γ	1958 Mar. 26.73 94 days	Cylinder 31 lb.	80 in. long 6 in. dia.	1958 Mar. 26.73 1958 April 9.05 1958 June 14.13	33·3 33·3 33·3	115·7 110·4 96·8	101 100 93	1,511 1,251 565	0·166 0·140 0·063	— — −124
Sputnik 3 .. 1958δ2 instrumented cone	1958 May 15.3 2 years	Cone 2,926 lb.	12·3 ft. long 68 in. dia.	1958 May 15.3 1958 June 5.7 1958 July 9.2	65 65 65	105·985 105·700 105·300	122 122 122	1,013 1,000 979	0·111 0·110 0·107	−32 −39 −50
Sputnik 3 .. 1958δ1 rocket	1958 May 15.3 7 months	Cylinder? —	— —	1958 May 15.3 1958 June 8.1 1958 July 2.2	65 65 65	105·985 105·000 104·000	122 121 121	1,013 964 914	0·111 0·106 0·100	−32 −40 −48
Explorer 4 .. 1958	1958 July 26 4 to 5 years	Cylinder 38·5 lb.	80 in. long 6 in. dia.	1958 July 26	51	110·28	163	1373		

NOTES.—Oct. 4.90 means 21 hr. 36 min. G.M.T. on 4 Oct., 1 n.m. = 6,080 ft. Perigee and apogee heights for Sputniks are over an earth of radius 3,435 n.m. The values for the Sputniks are from observations and theory. Those for the U.S. satellites have been compiled from a variety of sources, and there may be inconsistencies.

Truth or Ignorance

By A. R. ACRAMAN, B.SC., A.R.I.C.

The Critics

"Why should enormous sums of money be spent on the investigation of space, when no apparent material gain will be forthcoming?" "Why should useful citizens be allowed to throw away their lives in pursuit of a useless scientific experiment?" "Has not Man already overstepped himself in the great scientific discoveries of this generation?" "The probing of space represents further interference with the secrets of nature which may well lead to Man's ultimate oblivion."

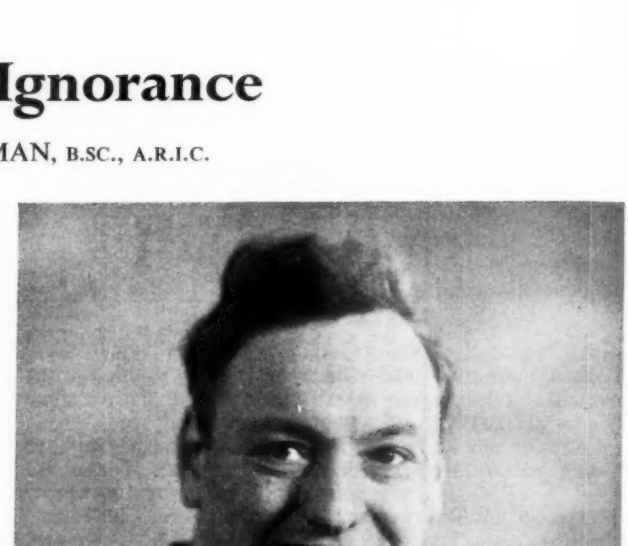
Such comments are often made, and the writer will attempt to explain why many eminent scientists and laymen believe that space exploration is a natural development of Man's insatiable thirst for knowledge, and must be carried out to the utmost of Man's ability.

Man's Power to Reason

Zoological and medical investigations have shown beyond doubt that physically, Man differs but little from the higher animals. The essential difference between *Homo Sapiens* and the higher animals appears to be "Thinking Man's" ability to reason and create systems of thought. Underlying all Man's achievements of civilization and science, is his desire to probe the unknown. It was this passionate desire to know what lies beyond the horizon that led to the discovery of new continents and ringed the Earth with systems of communication. Without this inquisitive desire to learn where, how and why things exist, Man degenerates to a state of mental stagnation, as can be well illustrated by the Aborgines of Australia, whose life and customs have not apparently changed much since very early in human history. Behind Man's thirst for knowledge lies a prime motive, or driving force, which, although he may not realize it, is based on his ever present desire to solve satisfactorily the meaning of his existence, and of his place in the universe.

Man is gifted with power to reason, a factor which places him far above any animal. To suppress this power in any way is morally wrong. Reasoning can only lead to truth if facts are known, and unbiased scientific investigation is the only sure means of obtaining these facts. It is obvious that, if Man's wonderful gift of reasoning is to be fully exploited, most scientific investigations must proceed without restriction, especially in Man's future endeavours to conquer space.

It is difficult to realize the exciting thought that the advent of space exploration is so near that there may be young people alive to-day who will be privileged to live in an era when some of the most baffling mysteries of the universe may be at least partially solved.



A. R. ACRAMAN

The Structure of the Universe

In order that the significance of the problems relative to space can be more easily appreciated, it is necessary that the reader should understand a little of the vastness and complexity of the universe. Until the beginning of the seventeenth century, the generally accepted interpretation of the universe was extremely crude. The Earth was thought to be situated at the centre of the universe, and the Sun, Moon, planets and stars were believed to revolve round the Earth. The stars were thought to be sources of light suspended on the inside of a spherical shell surrounding the Earth. The function of these stars was religiously thought to be that of making the night a little brighter. Such ideas may seem to us a little naïve, but in those days they were held with such fervour that men were persecuted for daring to doubt or believe otherwise.

Far from being the centre of the universe, we now know that our Earth is but one insignificant speck in the Great Unknown, and the Sun but a medium sized star.

The Earth is one of a number of small spherical bodies called planets which revolve round the Sun in regular paths or orbits. The diameter of our Sun is known to be approximately 864,000 miles, which means that the volume of the Sun is more than one million times that of the Earth. The Sun and its nine major planets constitute the greater part of what is called the "Solar System". These planets vary in size and distance from the Sun. Mercury, the nearest planet to the Sun, has a diameter about one-quarter that of the Earth, and moves round the Sun at a mean distance of 36 million miles. The outermost planet of the solar system, Pluto, lies at a mean distance of well over 3,000 million miles from the Sun. Earth describes an orbit 93 million miles from the Sun, and is a relatively small planet, having a diameter of nearly 8,000 miles. The largest of the planets, Jupiter, has 1,300 times the volume of the Earth, and lies 483 million miles from the Sun. The remaining planets, Venus, Mars, Saturn, Uranus and Neptune need not be described, as the reader has now some indication of the dimensions of our solar system. These great distances are not easily conceived by the layman, but it is hoped that the following analogy may help.

If the Sun is represented by an average sized orange, then the Earth on the same scale could be represented by a grain of sugar 33 ft. away. Jupiter could be represented by a large pea 180 ft. away, while the furthest planet, Pluto, would be about the size of a tomato seed situated one-fifth of a mile away. The distances involved in the Solar System may seem enormous, but the distances of even the nearest stars to the Sun are so great that another form of measurement has to be used. The term "light years" is used, and the nearest star to our Sun is approximately $4\frac{1}{3}$ light years away. This means that light, travelling at 186,000 miles per second takes over four years to cover the distance. In order to appreciate the significance of these figures, in terms of the orange analogy, an orange representing the nearest star would, on the same scale, have to be placed 1,500 miles away from an orange representing the Sun.

It is now known that the Sun is a medium sized star situated in a cluster of stars known as a galaxy, the general outline of which is shaped rather like an elongated doughnut. The dimensions of this star system are so enormous that it takes 120,000 years for light to travel from one end to the other. In spite of this inconceivable multitude of stars, the distances between them are so great that the total volume of all the stars compared to the total volume of space in the galaxy is vastly less, by comparison, than the volume of one raindrop to the waters of all the oceans of the Earth.

If this galaxy were the total extent of the universe, it would indeed be awe-inspiring, but this is not the whole story, because we know that other galaxies exist, although these lie thousands of light years away. Millions of galaxies similar to our own exist in outer space.

It is hoped that this very brief word picture has illustrated the basic structure of the known universe, but one final and important fact must be remembered: the system is not static, as every body in the universe is in motion. The planets revolve round the Sun at various speeds; the Sun itself is moving through space at thousands of miles per hour, and all the stars in the universe appear to be moving at various velocities. The most startling movements of all are those of the individual galaxies which appear to be moving away from one another at tremendous speeds. Science has revealed that as the distance between our galaxy and other galaxies increase, so the rates of their relative velocities also increase. The most distant galaxies which can be detected appear to be moving at the staggering speed of nearly 40,000 miles per second, which is more than one-fifth the speed of light.

The Hostile Universe

Modern science has displayed to us the existence of a universe so vast that it is not possible for the human mind to realize the size of even a minute fraction. An intelligent person possessing even an elementary knowledge of the known extent of the universe must be filled with awe and wonder at its fantastic immensity and complexity, and when we realize the absolute insignificance of our Earth in this cosmic scene, we must inwardly tremble with apprehension.

What is the meaning of this universe? Where does the human being and life fit into this vast plan? Can we believe that an ordered dynamic universe working and moving to definite laws can have been created for no reason whatever? Man, being what he is, demands that there must be a purpose in the existence of the gigantic system. Is life part and parcel of this system, or is life completely alien to it? It may well be that life on this Earth is existing in a hostile universe, the purpose of which has nothing whatsoever to do with life. We may recoil at this idea, but the possibility must be faced, because the answer to this question is of such fundamental importance that, if known, it could have tremendous repercussions on philosophical and religious thought. Many learned men have expressed the opinion that the origin of life on this Earth was the direct result of a chance combination of atoms and molecules under favourable conditions. This combination is thought to have resembled a complex protein type molecule capable of utilizing surrounding molecules in order to duplicate or reproduce itself. It has been suggested that the possibility of such a chance combination is so remote that even if there were hundreds of millions of planets similar to the Earth, not more than one would be likely to produce life. However, we must not delude ourselves about this; if a rudimentary life form created by chance is assumed, then there is overwhelming evidence to show how this entity could have developed into more complex forms, culminating in the production of higher animals and finally, Man.

If the above theory is accepted, then there is little doubt that Man is indeed living in a hostile universe, in which life is not part of the scheme of things, but is in fact an

abortion of nature. If this is the case, then it is a terrible and hollow joke that Man should have developed the power of thought and reasoning only to prove himself a freak of nature. This purely cynical and materialistic point of view is not necessarily subscribed to by the writer, but since scientific inquiry cannot take religious and philosophical beliefs into account, it is necessary to show what sort of conclusions can soon be arrived at by relying only on the limited amount of scientific knowledge which is at present available.

A New Age of Enlightenment

The first and most important problem then, in Man's quest for the true understanding of life, is to solve whether or not life is part of the natural plan of the universe. One may well ask "How can this problem possibly be answered with scientific accuracy?" The startling truth is that in the near future great steps will be made towards the revelation of life's place in the universe. The investigation of space will be the path along which these scientific inquiries will be made, and those of us who are fortunate enough to be alive when the conquest of space begins, will be privileged to see what might well be the dawn of enlightenment with the ancient walls of prejudice broken down for ever.

Great new scientific discoveries will be made, not only by visiting other planets, but by observations made from artificial satellites built by Man in space thousands of miles above the surface of the Earth. It is a sobering thought that, in spite of all our present knowledge of the workings of the atom, we still cannot explain the true nature of matter. Science can show that basic particles such as electrons, protons and neutrons combine to form atoms, but cannot explain the make up of these basic particles. It is thought that these particles are completely converted into energy under certain conditions; and that mass and energy are interconvertable. From that it must be concluded that matter is a form of condensed energy. But what is energy?

It may well be that Man is rapidly reaching the limit of knowledge that can be gained within the confines of Earth itself, so that logically the next great step to take, must be the conquest of space. Observations and experiments carried out in space will help in the understanding of the true nature of matter and related problems, such as the phenomena of gravity, and the true nature of electromagnetic radiations.

The Tenacity of Life

If life, as we know it, exists elsewhere in the universe, then conditions must be present to sustain it. Such conditions, as far as we know, can only exist on planets which revolve round a parent sun. The secret of the successful continuity of life is its adaptability to prevailing conditions. If this were not so, life on Earth would have been liquidated at a very early stage of its development. Life is not a stagnant phenomenon, but is constantly changing with conditions and environment. Because of this plasticity, it is possible that once life has been created under suitable conditions, it can remain in existence under almost any future condition except that of extreme heat or extreme cold, providing conditions change slowly enough for some form of evolutionary adaptation to be accomplished. With this in mind, the possibility of life surviving on any other planet cannot be dismissed completely. It is not yet known for certain whether there are any planetary systems existing other than round our Sun. This surprising lack of knowledge is due to the fact that planets, having no light of their own, are only seen when they reflect light from their parent sun. As the nearest star is several light years away, the reflected light from any distant satellite would be too weak to be observed by any telescope on Earth.

Artificial Satellites

With the development of manned artificial satellites out in space, scientists will be able to install telescopes so large that the details of some of the nearest star systems will be clearly visible. On Earth, the effective range of an astronomical telescope is limited by the filtering and refractive effects of Earth's atmosphere. Telescopes in space will not be subjected to these limitations; it will therefore be possible to prove conclusively whether or not the nearest stars have planetary systems revolving round them. If only one other planetary system can be discovered, the universe is so vast that we could logically conclude that a planetary system is quite a regular occurrence, and the universe could be considered as containing hundreds of millions of possible abodes of life. If such planets do exist, we could never hope to reach any of them by space travel as it is currently envisaged, because these journeys would take many thousands of years to complete. Unfortunately, therefore, definite proof of the existence of life on these far away planets is not likely to be forthcoming. Seekers of the truth are not daunted by this, because, fortunately, we always have the planets of our own Solar System, which, by comparison, are relatively close to Earth and during the conquest of space a number of these will undoubtedly be investigated at close range.

Of all the planets in the Solar System, Mars offers conditions nearest that of Earth. Mars has an atmosphere which may possibly contain a very small amount of oxygen, and has a limited quantity of water. The planet spins on an axis in a similar manner to Earth so that seasonal climatic changes occur. As Mars lies approximately 140 million miles from the Sun compared with the Earth's 93 million miles, the seasonal temperature variations take place considerably lower down the scale than on Earth. For example, the equatorial temperature of Mars is approximately equivalent to that of a May day in central England. From this brief summary of Martian conditions, it seems probable that some life forms could live there. Many astronomers do in fact believe that life of a kind does exist on Mars. Considerable evidence has been put forward in favour of this theory; for example, certain parts of the planet's surface

are known to undergo seasonal variations in outline and colour. This can be explained by postulating the existence of plant-like forms which change their colour as the seasons change, in a manner similar to many of our own plant species. The real solution will only be forthcoming when the planet has been visited by Man.

In all probability, the first heavenly body to be investigated will be Earth's own satellite, the Moon. This is one of the least likely places in which we expect to find life. There is no appreciable atmosphere, and no water. The surface consists entirely of non-heat absorbing material which reflects almost all the heat and light from the Sun. Because of this, the surface temperature during the lunar day is hot enough to boil water, while at night the temperature drops almost immediately to far below freezing point. In spite of these terrible conditions, a number of authorities on the subject believe there is a faint possibility that a low form of life may exist in certain craters on the Moon. This assumption would explain the appearance of certain dark irregular patches on the walls of some lunar craters, the shape of which appear to change from time to time. If this is true, it portrays a startling example of the tenacity of life and life's ability to survive appallingly adverse conditions.

Conclusions

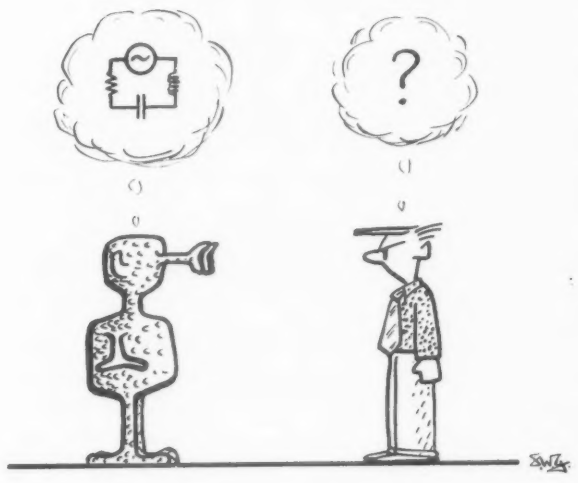
The motives which inspire Man to delve into fundamental scientific research depend basically on his innate desire to explain the nature of the universe and life's position in it. Before any sound universal scientific philosophy can be founded, the true nature of matter, energy and life must be explained. Whether or not these questions will be answered may depend on the success or failure of Man's future conquest of space.

The question which concerns Man personally is the explanations of the part life has to play in the universal plan. It has been shown that life may be alien to the universe, existing temporarily in a hostile universe as a parasite on Earth. On the other hand, life may be present as a natural sequence which is found to occur if conditions are favourable. If life in any form whatsoever is found on any other planet the consequences would be profound; for this might be in some ways regarded as Man's *greatest and most wonderful discovery of all time.*

If the presence of life is discovered elsewhere in the planetary system, we can logically conclude that life is not just an unhappy accident of nature, but a natural consequence of nature, that the phenomenon of life is not a fugitive in a hostile planetary system, but part of a natural order governed by universal laws.

Should it be proved beyond doubt that life exists on any solar planet other than Earth, and we discover by means of space telescopes that other planetary systems exist, then we can but conclude that many of these planets are also abodes of various life forms. No longer could we then think of the universe as a massive dynamic system bearing no relation to life; on the contrary, we should be forced to admit that in all probability this universe of inconceivable dimensions is teeming with life of all kinds. If this is true, how much more wonderful the universe will seem. We can attempt to imagine the diversity of life forms, and conditions under which they may live. Each abode of life would have its own evolutionary history culminating in its present end product. Some of these life forms may possess intelligence comparable with our own. What is even more likely, many different entities throughout the universe may have far exceeded our own standards of intelligence, and may even have solved the most vital secrets of nature and the meaning of the universe.

The day when ultimate knowledge of the universe is gained by Man may be very far off, but the writer believes that by the pursuit of knowledge by scientific methods, the truth of life and the universe will eventually be found. It may take thousands of years, but some day in a much enlightened age, men will cease to hate one another and join together in a common universal philosophy, for ever seeking the truth.



Hydroponics

By STEPHEN KEELER, F.R.A.S., Member, Hydroponic Fellowship

When spaceflight has really begun, "hydroponic farming" will certainly be of great importance. This article gives an introduction to the subject.

Much has been written in the past about the possible use of hydroponics for producing an oxygen supply for the crews of space stations on airless planets, and there is no doubt that controversy will rage for some time as to whether plant life can produce oxygen for future space-travellers. This scientific method of growing plants is not new; and, indeed, the first experiments were being made as much as 50 years ago, but it was not until comparatively recently that the first public demonstrations were made. Scientists in several countries have produced most successful results in growing plants without soil; which is not surprising because in hydroponics the plants have direct access to all the necessary elements, in the right proportion, for successful growth. Whereas in soil it is quite often a case of a deficiency of some element vital to the plants or, just as bad, a surplus, in the hydroponic tank all the chemicals are correctly balanced and can be adjusted when ever the need arises.

One of the main features of hydroponics is its simplicity, in that no elaborate equipment is needed; moreover, it is not expensive. The cost of chemicals is almost negligible compared with conventional soil growing, and the results are vastly superior. There are many critics of this method of growing plants who say it is not natural, and that food grown this way cannot be the same as that grown in soil—in other words, that it will be "too chemical". This is absurd, of course, because after all, the plants are fed on the same chemicals as they would get in soil, and they seem to thrive better in the hydroponic tank. For instance, tomatoes grown for a whole year in the hydroponicum, are said to keep better after picking than soil grown tomatoes; they are well fleshed, and certainly taste no different to soil-grown varieties.

There are two types of hydroponic culture, namely, water culture and aggregate culture. The equipment needed for water culture is quite simple, the tanks being of wood, concrete, or glass. Stainless steel is best, of course, but is so expensive as to be almost prohibitive. If any other metal is used, care must be taken to ensure it is well painted with asphaltum paint to prevent elements toxic to plant life being introduced to the chemical nutrients. Size of the tanks depends on the requirements of the grower, but in all cases the depth must not exceed 10 in., usually 6 to 8 in. is the depth employed. The formula for chemical nutrients depends on the type of plant being grown; thus, for instance, for green vegetables, such as cabbages, a higher percentage of nitrogen would be incorporated in the nutrient.

Growing can be started from seed, or alternatively young seedlings can be introduced direct to a tank, wire netting being the medium of support at first and then normal staking when the plants have reach full growth. It must be remembered that only the roots of the plants should have actual contact with the nutrients, and the solution must be kept at a steady temperature of 65-70° F. Periodical tests are necessary to ensure that the correct chemical proportions are being maintained in the tank, although the plant themselves will soon show visible signs of anything amiss, and a nutrition test will soon reveal the trouble, this being quickly rectified by the addition of whichever element is required. Such element or elements being immediately assimilated and therefore of immediate benefit to the plants. Essential food crops such as potatoes, carrots, onions, etc. give prolific yields in the hydroponicum, and are planted closer together than soil-grown types; therefore less space is needed, because the roots do not have to search for food but are in direct contact with all the elements necessary for successful growth.

In aggregate culture, the tanks are similar to those used in water culture except for sub-irrigation channels running through the base of the tanks. Formerly these tanks were filled with a mixture of sand, gravel, etc., but nowadays there are one or two excellent aggregates being manufactured which are far superior in every way. These aggregates are supplied ready charged with sufficient chemical nutrient for 14 days, after which period the plants are fed with further chemicals as required by means of sub-irrigation. A high capillary action ensures a constant supply of nutrients in direct contact with the roots of the plants. Growing from seed is very simple and amazingly economical in that there is no waste. When pricking off young seedlings, all the seedlings can be planted immediately into other tanks, and such transplanted young plants show no sign whatever of having been moved, the primary reason being that there is no damage to the delicate root hairs when the plants are moved. In a simple experiment last year one packet of tested seed was sown in a small seed tank. Germination was virtually 100 per cent., and when the seedlings were just four days old they were thinned out to 4 in. apart. The seedlings pricked out were transplanted into other tanks, and the final result was a crop of 135 fine healthy plants from one packet of seed.

The advantages of hydroponic culture are enormous, there being no soil pests or disease to contend with, and growth can be controlled at all times. Seasonal

Tomatoes Dwarf Amateur
Courtesy of Mullard Horticultural Ltd.

Trough type tank. Sub-irrigated
Courtesy of Mullard Horticultural Ltd.

growth goes by the board as any type of plant can be grown at any time of the year and a full cycle of growth maintained, the only requirements being a steady temperature of 65 to 75° F., and sunlight, either natural or artificial.

So much for the fact that plants can be grown successfully in hydroponic tanks, but will these plants be able to take care of the problem of supplying oxygen? There are many factors which point to an answer of "yes", and a study of plant life reveals many interesting points. We know, for instance, that plants can, and do, absorb carbon dioxide from our atmosphere. Proof of this is evident in a simple experiment where a plant is grown in either soil or tank in which there is no trace of carbon; yet on analysis half the dry weight of the plant is found to consist of carbon, such carbon having been absorbed by the plant from the atmosphere. Plants are found to breathe by means of tiny pores known as stomata, on the underside of the leaves. Oxygen is separated from the carbon dioxide and transpired, while the carbon, together with the remaining hydrogen, and in the essential presence of water, sets up a series of carbohydrates which are distributed throughout the plant in the form of sugars, etc. This chemical process is known as photosynthesis, and without it all life on our planet would perish. It has been said that plant life is solely responsible for the high oxygen content of our atmosphere; in any case, study of plant life brings forward many points in favour of such being possible.

There is a definite place for hydroponics in any venture into space for air purification, a supply of fresh greens, etc. Even if it were to be proved that plants could not supply enough oxygen to maintain an earth-type atmosphere in a space-station, it is obvious that by absorbing carbon dioxide, they will purify the air of such poison, thereby prolonging the life of an artificial atmosphere. The layout of a space station on Mars would be very simple, and presumably would be dome-shaped or even underground. Next to the living quarters would be the hydroponicum; the air from the crew's quarters would be circulated through the hydroponicum and back again. The plants, consisting of essential greens and vegetables to augment the limited diet of the crew, will be serving a dual purpose by purifying the air.

A hydroponicum would have a great physchological effect on the crew, who after all, will be millions of miles from their home planet, and the sight of earth-type plants in full growth could well allay a yearning for home. In view of this, part of the hydroponicum could be planted with a choice variety of flowers and shrubs in the form of a small garden. The question of supplies is not a formidable one, as a huge quantity of seed will take up very little space, and the aggregate, which is exceedingly light in weight, will last for years, while the amount of water needed is not excessive. Heating could be supplied by ultra-violet lamps, which at the same time would give out the light rays necessary for the natural process of photosynthesis.

One thing is certain: when the spaceships are ready for the first venture to the inner planets, the hydroponicists will have had years of experience and success with their new branch of science.

Glossary of Astronautical Terms

By D. HURDEN

A useful guide for those who may not be familiar with some of the expressions found elsewhere in SPACEFLIGHT.

Aphelion — The greatest distance from the Sun reached by a body travelling in an orbit around the Sun. (Cf. "Perihelion".)

Asteroid — Any one of the very small planets or bodies rotating around the Sun in an orbit lying mainly between those of Mars and Jupiter. They range in size from about 500 miles in diameter to large lumps of rock.

Atmosphere — A gaseous envelope surrounding a heavenly body. The Earth's atmosphere has been arbitrarily divided into several layers. (See Exosphere, Ionosphere, Stratosphere, Troposphere.)

Characteristic Velocity — The velocity which would be reached by a rocket-propelled vehicle in the absence of gravity, having used all its propellents. It is also equal to the sum of all the changes of velocity undergone by the rocket if the propellent is used in several bursts. It is derived from the equation

$$v_c = v_e \log_e \frac{M_o}{M}$$

where v_c = critical velocity
v_e = rocket exhaust velocity
M_o = initial mass of rocket
M = final mass of rocket.

Circular Velocity — The velocity needed by a body to keep it in a circular orbit around a parent body. At this velocity the centrifugal force tending to cause the body to fly outwards, balances the gravitational forces pulling it inwards: as the distance between the bodies increases the velocity necessary decreases.

Escape Velocity — The lowest velocity with which a body must leave the Earth or other planet so that it will not return under the influence of gravity. For the Earth, this is about 7 miles/second: for the Moon it is only 1·4 miles/second.

Exosphere — The outer and least dense layer of the Earth's atmosphere, stretching from an altitude of about 500 miles to interplanetary space. It contains only about one 10,000 millionth of the total weight of the atmosphere.

Gibbous — The state of the Moon or a planet when its visible part is greater than half but less than full.

Ion — A molecular or atomic particle which has gained or lost an electron so that it is electrically charged.

Ionsphere — The third layer of the atmosphere, between altitudes of 50 and about 500 miles. In this region solar radiation splits off electrons from atoms and molecules of atmospheric gas rendering them electrically charged. As a consequence radio waves may be reflected from this layer.

Mass Ratio — The ratio of the initial total mass of a rocket to the final mass after the propellents have been burnt. Care should be taken before using this ratio too freely in the calculation of the size of step rockets: its use requires some thought.

Minimal Trajectory — The path followed by a rocket vehicle travelling between two fixed terminals in space so that the least possible amount of fuel shall be used.

Occult — (*Verb*) Eclipse. A star is occulted when a planet passes between it and an observer.

Orbit — The path of a body in space acted upon only by gravitational forces.

Orbital velocity — The same as Circular Velocity.

Perihelion — The least distance from the Sun reached by a body travelling in an orbit around the Sun. (Cf. "Aphelion".)

Perturbation — The departure from its calculated orbit of a body travelling in a path about some centre, the departure being caused by other gravitational pulls than the central one.

Stratosphere — The second layer of the Earth's atmosphere, containing about a quarter of the wieght of the whole and extending from a height of about 5 or 10 miles to about 50 miles.

Telemetry — By derivation "measurement at a distance". The art of measuring various quantities and automatically transmitting those measurements by radio to a receiving station elsewhere. The method is of immense value for measuring quantities in a rocket or aircraft in flight.

Terminator — The boundary between day and night hemispheres of a planet or moon (e.g., the inner curve of the crescent Moon).

Troposphere — The lowest layer of the Earth's atmosphere. Between 5 and 10 miles in height, it contains about three-quarters of the weight of the whole atmosphere.

Dogs' Ascent in High-altitude Rocket

On August 29, the Russians announced that two dogs had been sent to an altitude of about 280 miles above the Earth, and had been brought down unharmed. The date of the launching was given as August 27. Apparently the vehicle was a one-step arrangement, carrying more than a ton and a half of equipment. The dogs' cabin was equipped with a system of regeneration, a separate system for recording biological functions, and a camera for filming the behaviour of the animals during flight. The dogs themselves weighed about 17½ lb. each, and had been thoroughly trained for their rôle.

The experiment was evidently most successful; and it is clear that before long work of this kind must lead to the first recovery of an animal from a satellite. Once this "re-entry" problem has been solved, yet one more of the so-called "impossible" difficulties facing space-travellers will have been eliminated, and the way will be clear for the pioneer manned satellite. This may well be achieved during 1959, always provided that the radiation hazards do not provide another serious obstacle. In any case, the Russian research teams have earned sincere congratulations for their work in this field.

How Long is the "Day" on Venus?

When future space-travellers reach Mars, they will find nothing strange in the alternation of day and night, since Mars has an axial rotation period of 24½ hours. With Venus, the position is less certain, and so far we do not yet know the length of the "day" there. Estimates range from 22¼ hours (J. D. Kraus in 1956) to 225 days (A. Dollfus in 1955). In the latter case there could be no true "day" or "night" over most of Venus, since the same hemisphere would be turned permanently toward the Sun.

Very recently Dr. R. S. Richardson has carried out some spectroscopic investigations at Mount Wilson Observatory; and although it seems impossible as yet to give a definite value for the rotation, there is some evidence that the period is neither so short as 22¼ hours nor so long as 225 Earth-days. All that can be said at the moment is that the rotation of Venus is likely to be longer than our own. Dr. Richardson's results are given in detail in the June 1958 issue of the *Publications* of the Astronomical Society of the Pacific.

Continued from page 307]

Electrical power sources.

The batteries supplying power for the various instruments are of the silver-zinc and mercury oxide type, designed to give a high output in relation to their weight.

In addition to these chemical batteries several solar batteries are installed. Converting solar radiation directly into electrical power, these batteries are composed of a number of elements consisting of thin plates of pure monocrystallic silicon, with an electronic conductivity set in advance. Four small sections of the battery are installed on the end plate, four sections on the side surface and one section on the end plate. This arrangement ensures that the batteries will function normally irrespective of the satellite's orientation in relation to the Sun. The overall efficiency of the batteries is estimated to be 10 per cent.

Orbit measurement.

The orbit of Sputnik III is similar to that of the previous Russian satellites. Its progress is being observed by radio technical and optical methods. Transmitters enable its co-ordinates to be measured along the orbit. These data are automatically reduced to a given astronomical time. Then, through special lines of communication, this information is transmitted to a common co-ordinating and computing centre where the measurements received from various stations are automatically fed into electronic computors which analyse all these data together, and calculate the orbit's basic parameters. On the basis of these calculations, the future movement of the satellite is predicted and the tables for its future position at any time given.

This highly complex measuring system, which includes a large number of electronic, radio-technical and other devices, ensures that the satellite's co-ordinates are measured with much greater accuracy than was the case with the first Sputniks.

In addition to this "official" watch, D.O.S.A.A.F. clubs (Society for Voluntary Assistance to the Armed Forces) radio direction finder stations and amateur radio "hams" are observing the satellite.

A 20·005 megacycle transmitter is continually transmitting radio signals in the form of 150 to 300 millisecond telegraphic messages.

The system for optical observations includes a number of stations outside Russian territory.

The foregoing makes it apparent that in the Sputnik III the Russians have a "space station" in the real sense of the term. It should add significantly to our knowledge of conditions in space up to 1,000 miles above the Earth, and it is to be hoped that in due course the Russian authorities will make the information being obtained available to other participants in the International Geophysical Year activities.

NEWS OF THE X-15

From DON KARSHAN

The X-15 rocket-propelled aircraft being built by North American Aviation Inc. is intended to bridge the gap between normal piloted aircraft and manned spaceships. Capable of carrying a man to an altitude of over 100 miles at speeds of over 3,600 m.p.h., it will enable us to add to our knowledge of the effects of "weightlessness" on pilots and will allow us to study in a controlled manner the problems that arise when a vehicle re-enters the denser part of the Earth's atmosphere at high speed after travelling in a near-vacuum. Some idea of these problems can be formed when it is realized that at a Mach No. of 4 the temperature of the aircraft skin will reach about 530° C.—a dull red-heat.

In order to withstand such high temperatures the skin of the whole aircraft is made of stainless steel, and much of the equipment inside it will be cooled by refrigerated air. Structural testing at representative conditions has called for great ingenuity and the use of up to 870 kilowatts of electrical power in infra-red heaters. Fig. 1 illustrates one test in progress.

Once it has been accelerated up to maximum speed by its rocket-engine, the X-15 will coast in a ballistic trajectory like an artillery shell. Once in this trajectory, no major changes of course will be possible, since the density of the air will be far too low for control surfaces to have any effect. The altitude of the aircraft will be controlled instead by jet reaction, small hydrogen peroxide "cold" rockets in the nose being used to correct pitch and yaw while similar units in the wing-tips correct roll. This is one method used to control large missiles and proposed for spaceships. The test-pilot has already learned to use it by means of a flight simulator, while the results of his "flight" are worked out by four analogue computers.

This remarkable aircraft is expected to fly during 1959. It is stated that it could be turned relatively easily into a recoverable manned satellite.

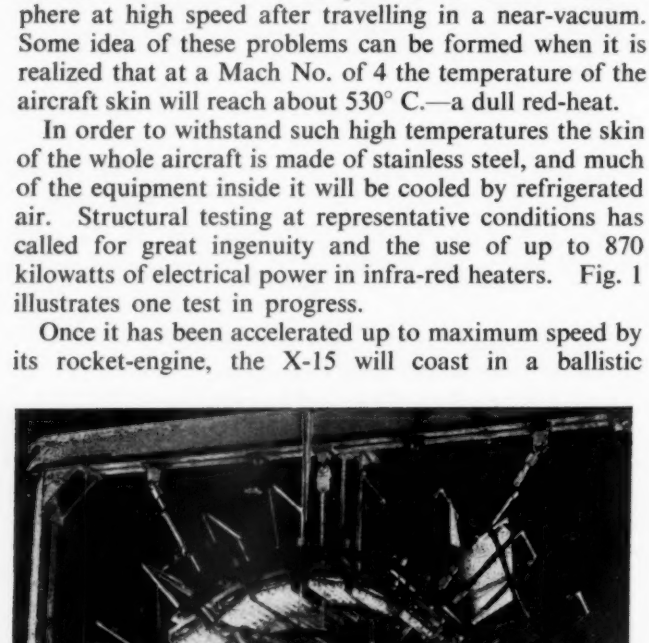


FIG. 1. *Triple Torture*—The triple torture of simultaneous heating and cooling of a metal ring representing a part of the X-15 fuselage is studied by North American structures engineers with a motion picture camera. Batteries of infra-red lamps heat the outside, while the ring is cooled from the inside by cold air blown through tubes. The structure of the X-15 is primarily stainless steel to combat high-temperature conditions

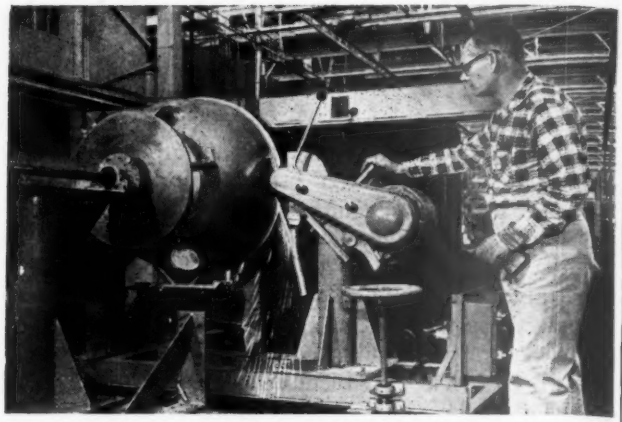


FIG. 2. *Trimming X-15 Spherical Fuel Tank*—The seam welded stainless steel spherical fuel tank half is shown being trimmed after drawing operation. Tank is for North American's X-15 research vehicle, made primarily of stainless steel to combat high temperature conditions

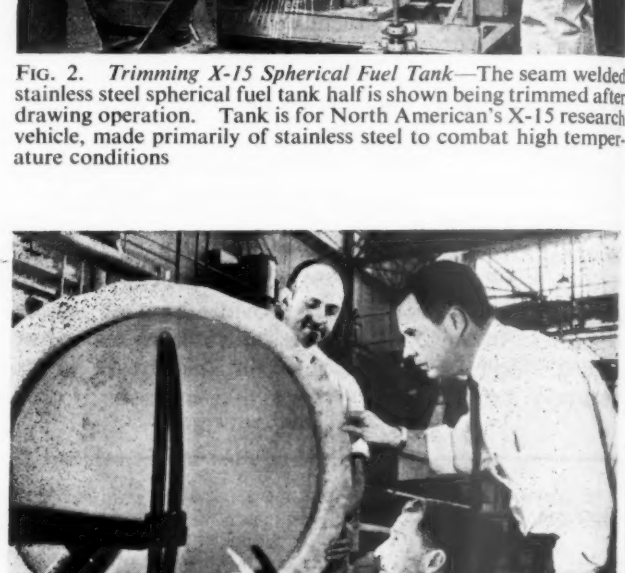


FIG. 3. *X-15 Fuel Tank Inspected After Spinning*—After drawing and spinning, the hemispherical end of a stainless steel pressure vessel for the X-15 rocket vehicle is inspected for thinning out by North American specialists in the forming of aircraft metals. The X-15 is primarily stainless steel to combat high-temperature conditions

August, 1958: The First Moon-shot

Everyone now knows that the first attempt by American scientists to fire a rocket to (or, rather, round) the Moon ended in failure. The basic facts are simply that the attempt was made on August 17; the launching site was the proving ground at Cape Canaveral; and that after a flight lasting 77 seconds, leading to an altitude of roughly 50,000 feet, the rocket exploded. But it would be wrong to draw the rather natural conclusion that the whole experiment was a fiasco, as some writers have tended to do. Let us examine the problem a little more carefully.

To begin with, the launching vehicle was—naturally—a complicated step-arrangement. Each time one adds a new "step" there is an extra risk that something will go wrong; every one of the many thousands of parts has to function perfectly, and the slightest trace of mechanical trouble will mean that the whole vehicle will fail. Rockets of the type used in the August experiment are relatively new, and it is a fair comment to say that they are still in the midst of their teething troubles. Moreover, this experiment was far more ambitious than anything previously attempted in human history. Never before has there been an effort to send a sizable vehicle far beyond the top of the Earth's atmosphere.

Much publicity had been given to the "Moon-shot"; in fact, probably much more than the scientists themselves wanted, since from the first they had made it clear that the chances of success were by no means really good. Correspondents from all over the world were standing by, ready for the latest news from Cape Canaveral, and preparations were going on in various places. Altogether over a dozen tracking stations were manned to report on the flight. Probably the most important of these was at Jodrell Bank, in Cheshire, where the great 250-foot radio telescope had been taken off its usual programme and been made ready to play an essential part in the tracking programme.

At first all seemed well. The 88-foot vehicle blasted away according to plan, but then came the tell-tale puff of white vapour and smoke as débris sprayed back into the Atlantic. Though the initial momentum carried the "Moon messenger" upward for a brief spell, the experiment was at an end. Tracking stations were notified accordingly, and the Jodrell Bank radio telescope returned to its normal programme. The official announcement, made from Cape Canaveral within a few minutes, said simply that "The space test vehicle launched at the Atlantic missile range this morning at 7.18 exploded after 77 seconds of flight. The U.S. will schedule further experiments at a later date."

All things considered, the wonder is not that the Americans failed, but that they got as far as they did at the first attempt. Even to time the launching itself within the limits of permissible error is a major feat, and this part of the programme seems to have gone without a hitch. At the time of writing (August 22, 1958) the causes of the subsequent explosion are not certainly known, and all that can be said is that some malfunctioning of one of the components in the engine compartments must be blamed.

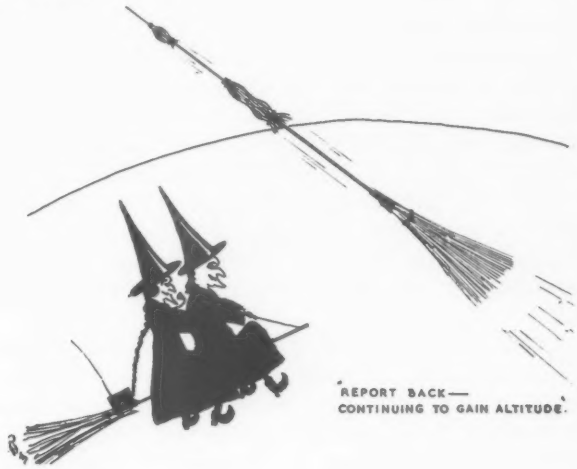
Neither is there any reason to be despondent. Though the first Moon-shot failed to reach the Moon, or even to leave the atmosphere of our own world, it has added a great deal of knowledge and experience; and this extra information will of course improve the chances of success next time.

By the time that this issue of *Spaceflight* appears, it is quite possible that a new attempt will have been made. Preliminary reports give a possible date as mid-September, and of course there is a very good chance that the Russian scientists will also make an effort to send a vehicle round the Moon. Surely it is only right, and in the true spirit of science, to dismiss any suggestion of a "space race," and to hope that success will come both to the American and to the Soviet workers. As a United States official commented immediately after the August experiment: "We will get to the Moon in the end."

THE EDITOR.

NEW LUNAR ATLAS

Dr. G. P. Kuiper, of Yerkes Observatory, is at present engaged in compiling a new photographic atlas of the Moon. Two well-known British lunar observers, E. A. Whitaker and D. W. G. Arthur, have recently left for America to collaborate in this work. It is hoped that the first part of the Atlas will be issued within the next year or so.



Sky Diary: October to December, 1958

A. E. SLATER

At 11 p.m. in mid-October, 9 p.m. in mid-November and 7 p.m. in mid-December (local time in the latitude of England), the Milky Way passes directly overhead and meets the horizon at the east and west points. At the same time, not far to the south of the overhead point, another Milky Way (or galaxy, or spiral nebula, or "island universe") is to be seen—the nearest one to our own and the only one visible without a telescope. It is the "great nebula in Andromeda", familiar in countless astronomical text-books as a photographic reproduction. But whether you look at it with a telescope or without, all you must expect to see is an oblong misty patch, with none of the fine detail shown in photographs.

It is oblong because we are looking at its disc-like form nearly edgewise, but if you bring your eye nearly down to the plane of the photograph and look along the length of the nebula, so as to make it appear almost circular, its spiral structure becomes obvious. Curiously enough, anyone looking at our own Milky Way (or galaxy) from the Andromeda nebula would see it just as oblong and just about as big. Each lies about 15° outside the plane of the other, each is about 100,000 light-years across; they are over 1,500,000 light-years apart. This means that each is 4° long, as seen from the other, though the bright central portion of the Andromeda nebula measures only three-quarters of a degree, and is all that the eye is likely to discern. The position of our Sun, seen from the Andromeda nebula, would be about 1° out from the centre of our galaxy; it would appear (in an instrument powerful enough to show it) as a star of about the twenty-ninth magnitude.

Looking at the Milky Way at this season, the observer may notice that the western half of it appears split in two. Dark obscuring clouds along the centre-line are responsible.

Earthly clouds, by the way, can also be "obscuring" and are well worth the attention of the sky-watcher. A general dimming of the stars can be due to clouds at two extremes of height: fog just above the ground, or thin cirro-stratus just below the stratosphere. Fog dims the starlight equally all round the horizon but the stars are brighter overhead. Cirro-stratus, which often produces a halo of 22° radius round the Sun or Moon, commonly heralds a depression, especially if the stars get rapidly dimmer towards the west, where the bad weather is coming from. If they do, don't wait up for the sky to clear.

A well-defined portion of the sky completely blacked-out, down to the horizon, with the rest of the stars as bright as ever, probably signifies a shower of limited duration, with perhaps more to follow at intervals; to quote Arthur Ransome in "Racundra's First Cruise": "Behind us in the north were patches of starlight, which, as we watched them, were swept into blackness, and then everything went dark in a sudden torrent of rain. Then again were patches of starlight with huge clouds chasing small ones, and then a great mass that seemed suddenly to swell out till the whole sky was gone and the hailstones rattled on the decks."

Then there are those aggravating clouds (to an astronomer) which stay put while the wind blows through them, and continually obscure something you want to see; they form in the lee of mountains and hills, and mark the tops of stationary air waves, like the stationary waves in a river downstream of a submerged boulder. They are commonest in the winter half of the year and in the nocturnal half of the day. The only remedy is to shift yourself a mile up or down wind.

Finally, there is strato-cumulus, a pattern of cloud "cells" with narrow slits of sky between, through which an occasional star shines; in this sort of sky the few stars visible look about two magnitudes brighter than the really are, so that you may mistake one of them for Vega and get quite disorientated.

The "Hunter's Moon" of October, like the "Harvest Moon" of September, is so called because the intervals between moonrise on successive evenings, around the time of Full Moon (October 27 this year), are shorter than usual, owing to the Moon's northward motion at this time. Another effect of this northward motion is that, when the Moon is near its last quarter in early autumn, it can be seen high in the sky around breakfast-time, shining particularly brightly because the sky is a much darker blue high up than low down (that is why a rough sea under a clear sky looks dark because the sloping wave-fronts reflect the sky overhead, whereas a calm sea reflects only the pale blue sky near the horizon; from this one might guess the colour of our oceans as seen from outer space).

High in the sky in the evening is the well-known variable star Algol, or Beta Persei (see diagram). It is a close double star, with a bright and a dull component. Every 2 days 20·8 hr. the dull one gets in front of the bright one and Algol goes dim—about as dim as the neighbouring star Rho; anyone interested can interpolate from the following times of minimum brightness: October 26, 20·2 hr.; November 15, 21·9 hr.; December 8, 20·4 hr.

Mars will be at its nearest on November 9, though it does not come into opposition until November 16, when it will be due south at midnight by local time (but at 11.45 p.m. at the longitude of Greenwich—work that one out!). It will then be higher in the sky than when it was in opposition two years ago, making its details easier to see through a telescope, though it was nearer then than now.

Let us, like Dr. J. G. Porter in his broadcasts, start with our own plant kingdom here below, where at this time the leaves will be colouring the countryside with their browns, yellows, reds and every shade between. This year the same colours should be seen simultaneously on Mars, though not because it is autumn on that planet too. It is not. The southern hemisphere of Mars, which is now turned towards us, had its Summer Solstice on August 11 and will reach Autumnal Equinox on January 18, 1959; so at the time of opposition it will be rather more than half-way through Summer. On Mars, those of the blue-green regions which turn brown do so in Spring and early Summer, so the change should by now have become well established.

These Martian colour changes, though difficult to distinguish from afar off, may well appear as brilliant and striking to anyone walking on Mars as our own autumn tints are to us; after all, the Earth's bright colours, when seen from a balloon at over 100,000 ft., become toned down to pastel shades, so Major David Simons has told us.

Telescopic observers will hope that the Martian atmosphere has recovered from its abnormal haziness of two years ago. But even at the best of times, G. P. Kuiper believes, the sky as seen from the surface of Mars will look white, not blue—yet another argument why the blue-green areas cannot be "seas", when there is no blue for them to reflect.

Erratum. In the previous Sky Diary (July issue, p. 298), the diameter of a Perseid meteor of 1st magnitude should be 0·094 in., not 0·94 in.

Blue Streak

The statement by Mr. Aubrey Jones, Minister of Supply, that Britain may undertake a satellite programme using the Blue Streak and Black Knight will be received with satisfaction by members of the British Interplanetary Society, for it was three of our number who originally proposed the development of "Minimum Satellite Vehicles" *seven* years ago.*

The B.I.S. can justly claim to have pioneered this aspect of scientific endeavour in the U.K. Indeed, the original B.I.S. design-study actually predated work on the American Vanguard and Explorer satellite schemes.

Blue Streak, the British Long-Range Ballistic Missile, is expected to have a range of 2,000 to 2,500 miles; according to Mr. A. Townley, Australian Minister of Supply, it is designed to drop an H-bomb within a target circle of 30 miles.

Clearly, with a weapon like this, we shall be able to play "trump cards" with the best of them in the Nuclear Club; but happily the Blue Streak is likely to be more than just a bomb carrier. Principal companies involved in the project are: de Havilland Propellors, Ltd., prime contractor under M.O.S. contract; Rolls Royce, Ltd., who will make the engines, and the Sperry Gyroscope Company, whose special concern is the guidance system.

As a weapon, the Blue Streak is officially stated to be superior to comparable American missiles, Thor and Jupiter; and both these missiles have now been adapted as first-stage boosters for lunar probes. It follows, therefore, that Blue Streak could also be adapted with suitable upper staging, to launch lunar probes and even, possibly, to send small instrument payloads into interplanetary space.

Black Knight, the other missile mentioned in the statement, is built by Saunders-Roe, Ltd., being designed for research into warhead re-entry problems. Firing trials began at Woomera on September 7. The first firing of Blue Streak, on the other hand, is not expected for another year to 18 months.

* "Minimum Satellite Vehicles," by K. W. Gatland, A. M. Kunesch, and A. E. Dixon, presented at the 2nd International Codgress on Aeronautics, in London, September, 1951.

Reviews

Men amongst the Stars. By W. Muller. Harrap. 300 pp. 18s.

In this book Muller sets out to survey astronautics in the very broadest manner possible, and this has been his downfall. Too much has been attempted and much of it has been treated in a somewhat superficial manner.

The style is a bright "digest magazine" type of English, carried along on a note of sustained breathless expectancy. This becomes specially wearing when the author deals with controversial matters, as in the chapters headed "Saucers under our skin," "Creatures that may await us," and "Religion in space"—and yet evades any definite conclusions. I found the continual use of rhetorical questions most irritating. Taking twenty pages at random I found at least one rhetorical question on every fourth page, and on page 230 there were actually 15.

The author is clearly most at home in the historical surveys of the development of astronomy and rockets, and these are the best parts of the book. C. A. Cross

Telescope Operation Manual for the Amateur Astronomer. By R. R. Dudley. Published by the author. 44 pp. 1 dollar.

This little pamphlet is expressly written for the person who has just acquired his or her first telescope. It sets out in a sensible and friendly way to assuage that burning fever of exploration which I expect we all feel at that breatless moment when we first set up our own telescope in the back garden (Americans read *yard*).

For such persons this book provides simple and timely guidance on how to use the telescope, and on what to look at, whilst leading gently and firmly to the proper use of more elaborate text books and star atlases, and to the more worthwhile activities which succeed this first intoxicating phase of just looking at all there is to see.

Some minor criticism can be made of the last three chapters. The author places the usual American amateurs emphasis on the importance of setting circles, whilst in this country it is generally agreed that they are much less important than almost any kind of clock drive. Again, the method of precise orientation of an equatorial mount is not perhaps the simplest and most elegant one. These matters will however be of little concern to the reader for whom the book is intended. C. A. Cross

Into Other Worlds. By Roger Lancelyn Green. Abelard-Schuman Ltd, London, 1957. 190 pp. 16s.

In the author's own words, this is "an attempt to describe the outstanding journeys to the Moon and planets in the writings of storytellers from Lucian the Greek near the beginning of the Christian era, to those of our contemporary Professor C. S. Lewis."

The attempt is a most successful one, and Green has produced a well-written, interesting work which cannot fail to enthral. As he points out, his book is descriptive rather than critical; of the other two important volumes on this subject issued since the end of the war, his work is therefore closer to Marjorie Hope Nicolson's *Voyages to the Moon* than to Patrick Moore's *Science and Fiction.* There is a useful bibliography.

From every point of view, this excellent book may be recommended without hesitation. Doubtless it will run to many editions. J. S.

Operation Vanguard. By Werner Buedeler. 2nd edition. Burke Publishing Co., 1958. 16s.

The first edition of this book appeared in 1957, shortly before the launching of the Russian Sputnik I. The publishers have been wise to issue a new version, fully up to date and with additional illustrative material. The new edition retains the excellence of the original; it is a really first-class account of the satellite projects, written in an easy style and thus very suitable for the beginner. H. W.

Book Set "A" obtainable from the Interplanetary Publishing Company. £1 4s. 6d.

Davidson, M. *Astronomy for Beginners*, 1948.
Inglis, J. Gall. *Easy Guide to the Constellations.*
Gamow, G. *Biography of the Earth*, 1948.
Bernhard, H. J., Bennett, A. B. and Rice, H. S. *Handbook of the Heavens*, 1957.
Various. *Complete Book of Outer Space*, 1954.
Moore, Patrick. *Guide to the Moon*, 1957.
Moore, Patrick. *Guide to the Planets*, 1957.

In these days of high prices, it is particularly gratifying to find seven books offered together at very small cost. The fact that all but one are paperbacks makes no difference, as in each case the print is very clear.

Davidson's *Astronomy for Beginners*, from the Watts "Thinkers Library," is by an eminent authority, and provides a first-class little introduction for the layman. It is well-illustrated with line drawings, and is in every way to be recommended. There have of course been developments since the book appeared, 10 years ago, but at this level there is very little to be altered, and the book deserves its popularity. The reviewer regards it as one of the best introductions known to him.

Gall Inglis' *Easy Guide to the Constellations* is also famous, and is most useful. It is perhaps fair to say that some of the charts could be improved—that of Cygnus in particular, where the novice will look in vain for the line of bright stars between Deneb and Albireo! However, this criticism should not be regarded as too serious, and the book is excellent value.

Gamow's *Biography of the Earth*, one of the excellent Mentor series, runs to nearly 200 pages, and is much more speculative; it seems curious that the author retains the old theory (now discarded by nearly all authorities) that the Moon was formed from the Earth, and there are other sections which are regarded as open to doubt. Nevertheless, the book is unquestionably worthy of close study.

Another Mentor book, *Handbook of the Heavens*, is longer (269 pages) and is extremely good; the amateur astronomical observer will find it particularly useful. There is a clear illustrated text, and plenty of invaluable tables, plus sections such as "the use of the telescope" which are not often to be met with, at least in so sound a form. There are 12 pages of photographs.

The Complete Book of Outer Space includes among its contributors Willy Ley, Wernher von Braun, Heinz Haber, D. H. Menzel, James H. Wyld, Oscar Schachter, L. R. Shepherd and R. P. Haviland. With such a galaxy of contributors the book should be first-class; nevertheless, the reviewer has to admit that despite the abundant illustrations, he found it by far the least satisfactory of the set. It needs revising, and there are numbers of mistakes and unsound statements, while the section "The Spaceship in Science Fiction" is lurid in the extreme. There is also a chapter on flying saucers. The glossary at the end is highly misleading; we learn, for instance, that at its nearest Mars is 65 million miles from the Earth, while there are many other instances of insufficient checking by experts.

Lastly we come to Moore's *Guide to the Moon* and *Guide to the Planets.* These two books were published some years ago, and quickly became accepted as the standard popular works.

All things considered, this set of books is excellent, and the money spent upon them will be well invested. K. E. S.

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October, 1956–October, 1958

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THE BRITISH INTERPLANETARY SOCIETY

The British Interplanetary Society was founded in 1933 to promote the development of interplanetary exploration and communication by the study of rocket engineering, astronomy and other associated sciences. It now includes among its members many British and foreign workers prominent in these fields.

The Society organizes meetings, lectures, exhibitions and film shows. These programmes are planned not only to assist the spread of technical knowledge, but to stress the limitless possibilities of rocket propulsion, and in particular the ultimate implications to human society of the crossing of space.

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